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MODELING IN THE MILITARY

Simple Simulation Models

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 3, 1977 signed to press 1 Feb 77 pp 10-11

[Article by Col V. Babich, Col A. Dubovitskiy, Col Ye. Lavrent'yev: "From Copying to Originality"]

[Text] Modeling in the military is employed primarily in three areas: in theoretical research, in studying personnel, and in analysis of the process of warfare. Simulation of flight is closer to the area of training in which a model performs the function of transmission of new knowledge to the pilot. In this article we shall be discussing the model and its copies, stages of simulation, utilization of models in preflight preparation, the diagram and model, and the advantages of simulation as a method of cognition.

Let us begin with the model and its copy. In the process of training, pilots frequently encounter simple models and elementary simulation. This can be demonstrated with the example of ordinary preflight preparation.

According to the schedule, the pilot is to perform two tasks: flight in the training area, and one-on-one free combat. The first task is not new to him. Having thoroughly studied the exercise, the pilot mentally runs through the sequence of performance of individual maneuvers, and then the entire sequence as a whole. He observes his aircraft from a vantage point, as it were, and puts together the complex flight path piece by piece: first the banked turns, then a chandelle, followed by a roll, a loop, additional rolls, and a slow spin.... If difficulties arise at any phase of the mental piloting sequence, he is assisted by methods elaboration of the exercise.

After running it through several times mentally, the picture of the flight becomes firmly fixed in one's mind. Failure to follow the proper sequence of maneuver execution is almost out of the question. During flight, control signals will proceed from the pilot's memory in the requisite sequence. There will be no excessive stress, and the pilot's attention will be fully concentrated on pure performance.

Can we call this effective method of memorization modeling or simulation? At first glance it would seem we can, for the pilot has created a mental analog or a simplified diagram of the flight, and he has performed in the air according to this scheme. However, an informal approach to the question suggests another answer as well.

Modeling is investigation of the properties of an object with its analog, while the process of investigation was lacking in preparing for the training mission. And since the model proper of flight into the training area had already been constructed by the authors of the exercise, had actually been flown and recorded in the training schedule, the pilot merely took a copy of it (which his assignment required), without introducing new elements.

The second flight is more complex, and in preparing for it, it is not enough to memorize or take a copy from a ready model. In free air combat each pilot will seek to be the first to enter the potential attack area and perform the graded sequence. A single goal is pursued, but there are many paths to attain it. These paths intersect. In the preceding flight involving a similar task, the adversaries proceeded right for one another and displayed equal piloting capabilities. Neither succeeded in taking an advantageous position to deliver ordnance, and the engagement ended in a draw. In order to achieve success now, it is necessary to surpass the adversary in tactical sharpness and present him with an unaccustomed problem. In this instance the flight configuration should be made considerably more complex. Needed here is a basic idea which arises as a result of analysis of factual material. Also needed is a close link between the logic of future combat on the one hand and the capabilities of the equipment and achieved level of flight performance on the other.

The theory involved is presented in a textbook, along with the tactical principles and procedure of calculations, but there are no formulas on how to act in each specific instance, nor will there be any. Therefore only well-developed tactical thinking, experience and knowledge can render real assistance.

The pilot takes airplane models and, displacing them in space, seeks possible methods of attaining a position advantage. It is difficult to gain the element of surprise. Therefore emphasis is placed on the feint. It is run through several times until the details have been refined. The adversary's behavior changes in each runthrough. Now begins an investigation and search for something new, that is, precisely those elements of modeling which were absent when preparing for departure to the training area. The results of the search indicate that the maneuver is enticing to the adversary, that one might readily succumb to it, and then miss the attack. A decision has been made -- this is the way to proceed.

Calculations establish a rigorous sequence of combat maneuvers and the actual contours of the entire flight path. The selected variant is substantiated in its principal parameters and differs significantly from the initial one. The pilot has added to his tactical arsenal and has taken a

step toward the summit of combat skill. This is movement forward, the achievement of a new position in the art of winning.

What is the main distinction between preparation for the second flight and preparation for the first one? As we have already noted, it lies in utilization of the simulation method, but in addition it also lies in displaying innovativeness, that is, the ability to find a correct solution in nontypical situations. Innovativeness and modeling are inseparably linked.

Let us examine the stages of simulation. In the first phase one selects an analogue for investigation or copying. The pilot assesses the structure of the object and compares it with existing models. In our example another engagement successfully conducted under similar conditions could serve as a model of the forthcoming air engagement. One should understand that there does not exist a complete copy of the flight for working up the elements of combat employment. The concrete situation compels one to make corrections even in an exercise performed for the second time.

During the Great Patriotic War records of the most instructive combat episodes were kept in many units; aircrews turned to these in preparing for their next missions. All useful elements were extracted from accumulated experience for utilization under concrete conditions. The idea of the concept, for example, was taken as a basis, and the diagram of actions would be changed. Successful devices employed in the most recent engagements would also be considered. Therefore the possibility of repetitive pattern was excluded, and it was difficult for the enemy to figure out what the plan was.

In peacetime a pilot can successfully borrow a device from the experience of an exercise, abstract from the specific factors and view this device as an analogue. If there is no ready model of the flight which can be taken as a basis, a new one is constructed. The method of construction depends on the complexity of the task and the time allocated for preparation. The path of the experimental flight, for example, can be fully calculated on a computer and then recorded by monitoring instruments. Specific conclusions are drawn on the basis of comparison. When time is of the essence, only the most critical elements of the flight can be modeled.

In the second phase (studying the model) the pilot's work boils down to seeking the most advantageous (optimal) variant of action within the framework of the assigned task. This is the way it was in our example of preparation for combat. The method of selecting optimal variants (comparison of experiment results) is demonstratively embodied in "walking through the mission," in which each pilot participated.

In the course of experiments -- bringing together and moving apart groups of "aircraft," restructuring formations, combat maneuvers and attacks -- the problems of the actual mission are resolved. After this phase is run through, the commanding officer makes corrections or alters the disposition

of forces in the air. If, for example, in the process of assembly one flight drew too close to another, the entire group returns to the "field," after which they again "take off" at greater time intervals.

Selection of a combat formation corresponding to the character of the assigned task is a process which always involves search. It is difficult to find a ready model for emulation. The pilots of past generations became convinced of this and passed down to succeeding generations the "walking through the mission." Today it is categorized as a component of simulation and most clearly depicts the possibility of studying the properties of a phenomenon on its analogue.

In the third phase (synthesis and concretization of results) one selects data obtained in the investigation and objective appraisal of conclusions. In other words, the expediency of verifying the model in the air is elucidated. The following requirements should be observed: no uncertainties should be left. Usually a principal and alternate variants are chosen, with a rigorously designated sequence of action. Concretization of conclusions is expressed in the flight plan, which is approved by the commanding officer.

It is important to remember that conclusions drawn on the basis of simulation can be recommended for extensive application only following practical verification. A battle won in the classroom by no means signifies a future victory in the air. However, firm prerequisites to achieve success already exist, since the pilot climbs into his cockpit with a ready game plan.

Now let us see how models are utilized in readying for a mission. In the process of practical flight activities, pilots employ various types of models on a daily basis. Models of the gunnery range and aircraft are object (material) models. They are based on geometrical similarity and analogous placement of structural elements and give a graphic picture of the external forms of the actual object. Pilots also frequently utilize tables and nomograms. These store requisite information. Many of them are the result of mathematical or electronic simulation and are called symbol models. Physical models -- gunnery and pilot training simulators which display the behavior of the object -- are extensively employed in the training process. The pilot is subjected, as it were, to conditions close to actual flight, and he even acquires flying or weapons utilization skills. The concept of flight model can best be assimilated on an operating flight simulator.

Frequently pilots use symbols, analogs -- in the process of learning. They are extremely simple and take up little space on paper, but they tell a good deal, provide all the necessary information on the actual object. The most graphic example of a symbolic model is the scheduled table of flight operations, in which a process which is highly complex in organization and execution is depicted with the simplest symbols. The planning table possesses properties which are mandatory for a model. It carries useful information and answers proper questions. The flight operations officer, using the

symbols and the time schedule as a guide, monitors not only the position of aircraft in the air but also the actions of each aircrew.

In addition to everything else, diagrams help pilots study their flight assignment. Frequently attempts are made to call any diagram a model, even a single curved line on a diagram running from an aircraft silhouette to the target. One can of course argue that this is an attack model, but it carries no useful information. A comparison with legitimate symbol models (for example, flight into the zone -- two circles) would not be correct. A diagram may become an attack model if it answers the question: what will happen if there is a change in altitude, speed, bank angle, G load or position of the maneuver initiation point? In other words, if a rapid recalculation of maneuver, transition to a concretely-assigned task is secured. Corrections for actuality can be taken from nomograms attached to the diagram. Then the diagram will provide the pilot with requisite information and even assist in elaborating a new tactical device.

Speaking of modeling a flight, one must discuss the question of notes and consumption of paper. The example of the planning table shows how intelligently one can make use of opportunities to economize in money, time and manpower. Naturally a pilot must resort to notes in order not to overload his memory. But there is a big difference between a symbol model designated for study (group utilization) and sketched for oneself. The former must answer the questions of all, while the latter only those of the single pilot (executor). Experience indicates that, glancing at a brief note, a pilot can give a complete, exhaustive answer. This is better than a vague answer based on a long note. The main thing is that which is contained in the pilot's memory corresponding to a symbol contained in the notebook. Thus the very process of modeling leaves in the memory of the executor not only the status of the object but also its principles of functioning.

In our opinion further elaboration and standardization of symbols -- sources of information -- would be very helpful to a pilot simulating a flight, just as he is assisted by knowledge of the symbols contained on the monitoring instruments, the radar screen or gunsights.

What are the advantages of simulation as a method of investigation and cognition of the new?

Simulation makes it possible to transfer a portion of experiments conducted previously in the air into the classroom or the simulator facility. Frequently a full-scale experiment in the field is very expensive or simply impossible due to the fact that the target item is not accessible to direct investigation, while a model provides an answer which, although incomplete, is adequate for further investigations.

Further, with the aid of simulation one can repeat an experiment again and again, until satisfactory results are achieved (selection of an optimal action variant), while input data and situation can be altered as the executor desires.

In addition, the model is examined in an accessible form, not distorted by random or unnecessary details. Running through the variants of the forthcoming training battle, the pilot eliminates the entire laborious process of flying the aircraft, although in flight it will give him a substantial share of the physical and psychological work load.

Simulation also provides the opportunity not simply to become acquainted with a given phenomenon but also thoroughly to understand its essence. Studying a flight assignment, a pilot cognizes its internal links and complex relationships and achieves a high quality of execution. Finally, the pilot learns in the process of simulation. He enriches his knowledge, expands his horizons and acquires the skills he needs as a specialist and air warrior.

In our opinion the main advantage of simulation is exclusion of the unsubstantiated decision. This is especially important both in practical flying activities and in military affairs in general, for during mental analysis, when making calculations, when seeking an optimal variant it is much simpler for the pilot and commander to be freed from subjective, superficial and inconsistent judgments.

At the same time simulation requires ability and persistence as well as the availability of auxiliary and methods materials. Therefore a certain caution exists toward simulation as toward any new thing. The most typical question is: "Can't it be done more simply?" In this article we have endeavored to show the effectiveness even of the simplest type of modeling. But can one expect simplification of methods of investigation when the process of armed combat proper is becoming steadily more complex?

At the present time there are no military phenomena for the cognition of which simulation would not be applicable. However, it cannot replace all other forms of preparation for a complex task. Construction of a model is pilot innovative intellectual activity, which has become particularly essential in a period of mastery of new equipment. (To be continued)

Optimal Attack Model

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 4, 1977 signed to press 2 Mar 77 pp 14-15

[Article by Cols V. Babich, A. Dubovitskiy, and Ye. Lavrent'yev: "Searching for a Better Variant"]

[Text] It is advisable to begin mastering simulation in the classroom, since it is in the classroom that pilots acquire or reinforce knowledge in several disciplines concurrently. Playing out concrete situations and decision-making in various roles can be effective methods thereby.

The former is characterized by the fact that the entire controlling role is concentrated in the hands of the commander -- the person in charge of the proceedings. He selects possible situations, alters the tactical situation, states concrete questions and analyzes responses. Relying on his own experience, the commander imposes his viewpoint on the pilot and brings those present to accept his solution. This form of training class is most acceptable in the initial period of training.

When utilizing the second method, the commander merely prepares scenarios and distributes roles. Pilots who have not been assigned roles take part in discussing intermediate decisions.

In order for truth to be born in innovative debate, the selected maneuver (device, mode of attack) is appraised from the standpoint of the capabilities of the equipment, aerodynamics and tactical expediency. Ready models elaborated by role executors can also be presented for group discussion. The leader merely introduces correcting conditions and makes the final summary of the exercise. The initiative is presented entirely to the trainees.

In order to determine the advantages of one model over another, the commander turns to his experience or suggests performance of calculations of probabilities of air defense penetration and of target destruction. Assessment and comparison of variants on the basis of quantitative indices is much more accurate and objective, but it requires employment of mathematics. Therefore it is essential to take into consideration the group's preparedness to perform calculations as well as the possibility of utilization of simple formula relations or ready nomograms.

As the pilot acquires simulation skills, the tactical problems should be made more complex. The selected situations should be more difficult to analyze. But the executing individual now has the opportunity to link his actions not only with guideline documents and manuals but also with previous solutions. There takes place the process of self-education, which is combined with exchange of know-how.

But how is a flight model constructed? In the previous article we examined some features of the process of investigation and stages of simulation. We shall now endeavor to reveal the content of the work performed by the pilot who is simulating a conventional flight problem.

The squadron had gathered in the classroom. The topic to be studied was flight simulation. They were to work with an exercise which included elements of tactics and combat employment. Thus there was observed here a link between theory and practice (objectivication of study). Models (targets) on the gunnery range were selected as analogs of targets and air defense weapons. The pilots were handed diagram cards on which were entered detection zone, automatic tracking zone, "enemy" weapons killing zone, target and battle line. The mission was to be flown in two-aircraft flights. Each flight was to hit the target, independently selecting the mode of attack.

The men are divided up into pairs in conformity with the schedule table.

The pilots may utilize all reference material available in the classroom. Solutions are recorded on the diagram card in written form. The flight leaders report the elaborated variants orally. The instructor compares them and selects the optimal solution on the basis of established criteria. The degree of detailing of the models and the method of assessing them are determined in advance.

As already noted, objectivity of analysis and reliability of conclusions are increased with the availability of quantitative characteristics. If a common variant for all is adopted for execution, it can be comprised of several solutions (after determining the strong points of each).

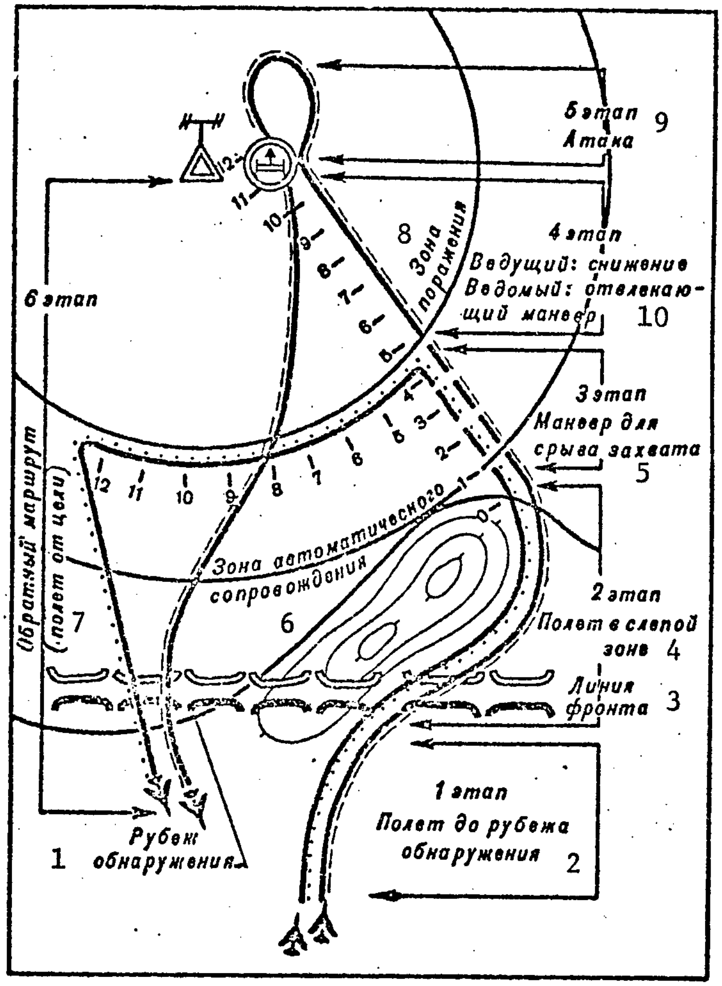
We shall join one of the groups of participants in the exercise and observe its performance.

Following a situation analysis the pilots determine that they are to elaborate an entire complex of devices and run them through on the gunnery range model. Unforeseen situations may arise at each point en route. Even a small error made long before reaching the target area can result in mission failure. In view of these considerations, the trainees break the entire flight down into stages: up to the point of detection by "enemy" radar, in the tracking zone, in the automatic tracking zone, in the killing zone, over the target, and on the return home.

Then the pilots determine what is the most important element at each stage. This investigation device is mandatory in the process of mission simulation. It makes it possible to concentrate attention on the most critical details which influence the end result. In addition sectors are determined where maintaining the planned mission conditions and maneuver parameters should be maximally rigorous (this means that calculations should be precise). Determination of the main element for each stage of a mission is nothing new to a pilot. In our case the main thing at the first stage is fuel economy, at the second -- concealment, at the third -- precision maneuver, at the fourth -- evasive action, at the fifth -- attack in minimum time, and at the sixth -- invulnerability during return to the destination field.

We should draw the particular attention of executing personnel on this stage of the investigation. It is precisely here that the rough model is born, its foundation, its skeleton. In other words the stones are being hewn which will be used to construct the pyramid. Actual construction follows. It is facilitated by the fact that the pilot is already acquainted with concealment measures, maneuvers to thwart lock-on, evasive action and various modes of attack. The principal difficulty in modeling a mission is rational placement of these elements stage by stage as the aircraft advances toward the target.

One must bear in mind that one and the same device may possess different effectiveness in a dissimilar situation. Foreign military experts, discussing the experience of local wars, attest that jamming when flying at low



Mission Model (variant)

Key to diagram: 1 -- point of detection; 2 -- flight to point of detection; 3 -- battle line; 4 -- flight in blind zone; 5 -- maneuver to frustrate lock-on; 6 -- automatic tracking; 7 -- return route (flight from target); 8 -- killing zone; 9 -- attack; 10 -- flight leader: descent; wingman: feinting maneuver; эman -- stage

altitude frequently did not conceal but revealed the presence of an aircraft. A maneuver employed against an antiaircraft system with one guidance system was not suitable for use against another operating on different principles of guidance. A dense combat formation in the detection zone concealed from the enemy the makeup of the attacking group, while in the killing zone it would become highly vulnerable. More examples could be given. They demonstrate the advisability of observing the principle of constructing a model: "At each stage -- the most effective maneuver (device)." This systematization facilitates elaboration of the overall logic and memorization of the sequence of actions in flight without referring to notes.

The first stage of the mission -- up to the "enemy" radar detection zone -- is not particularly complex in execution. In determining flight conditions, a medium altitude is chosen and the most fuel-economical speed. At a calculated point a descent begins, in order to enter the "enemy's" radar-covered zone as late as possible. One should bear in mind that when flying at low altitude an aircraft may not be detected at all by radar (then only three stages will remain -- to the target, over the target, and return).

This mode of mission execution, however, is complex, within the capabilities only of a highly-skilled pilot, and imposes limitations as regards physical work loads. In addition, ground navigation systems cannot be utilized, and arriving precisely on target is little probable.

The stage involving flight in the "enemy" surveillance radar tracking zone involves the necessity of concealing the flight. Concealment can be achieved by utilizing blocking obstacles (shadows) in the radar-covered zone or by concealing the aircraft on a clutter or jamming background. The pilots show preference for the former technique, since on the approaches to the gunnery range there is a hill which provides natural concealment almost up to entry into the automatic tracking zone.

The next, third stage is maneuver to prevent lock-on. The pilots choose from familiar maneuvers -- S-turns (heading maneuver) and alternate overtaking (speed maneuver). A calculation based on nomograms indicates that within the killing zone they can execute three S-turns with a turn of 60° with optimal airspeed and bank angles. Alternating passing offers a smaller probability of lock-on prevention (this applies to the specific system being employed), but requires less time, and the aircraft advance more rapidly toward the target. The pilots choose the latter maneuver. Important here is precise calculation of lead and lag, for disorganized "linking up" will not produce the desired effect.

The fourth stage is flight within the killing zone. Going over elaborated techniques in their minds, the pilots focus attention on vertical and horizontal splitting of the flight. The idea is as follows: immediately prior to crossing into the zone of initiation of fire, the wingman continues flying along the zone boundary (employs a feinting action), while the flight leader descends abruptly to low altitude while continuing to head toward the target. This device is intended to impel the "enemy" fire-control radar operators to track the wingman and lose the flight leader. The flight leader should attack the target at the moment the wingman reaches the maximum parameter. In order to be able to analyze various situations, the lines of possible aircraft track are broken down into minute (or half-minute) segments. At the fifth stage the flight leader attacks the target from a combat turn without a second pass. Withdrawal is in the direction of friendly territory without a climbout. Other techniques are acknowledged to be less effective.

The final stage is the return flight. Proceeding from the situation, it is continued to the point at which "enemy" low-altitude radar tracking terminates.

To prepare a report to the commanding officer, the pilots place the calculated flight path on the diagram card. It is shown in the figure in final form. The entire flight path, from the moment of entry into the "enemy" radar detection zone, is broken down into minute segments. These divisions may prove to be too large, particularly when calculating a flight in hazardous zones.

In spite of the simplicity, a model can answer questions pertaining to a specific mission. We shall enumerate some possibilities. How much time does an aircraft spend over "hostile" territory, and how can this time be reduced? What is the possible result of entering each stage late or early, proceeding from the degree of the "enemy's" readiness to repulse an attack? Is an attack on the target by the wingman feasible? Can a feinting maneuver be dispensed with? Is it not better to execute a "direct penetration" under cover of jamming?

It is important to note that in the given form the model does not answer the following questions: "What is the possible consequence of errors during alternate passing?" and "What will be the consequences of change in parameters of the combat turn?" The pilots studied the mission as a whole and did not elaborate models of combat maneuvers. Modeling of separate mission elements is performed with another method and constitutes a separate topic.

As a rule questions pertain to combat effectiveness, which reflects the results of the strike and the quantity of friendly losses. To answer these questions it may be necessary to refer to graphs or nomograms. The question "how will the probability of penetrating air defense or hitting the target change if..." requires the availability and recalculation of quantitative characteristics. We shall note that it applies more to the forecasting method, although it may be primarily of interest to the commanding officer.

Thus the model depicted in the figure constitutes a reduced-scale flight path projected onto a plane representation of the earth's surface. With this model one can study an actual mission with certain limitations. The pilots had at their disposal a sufficient quantity of informational material and applied a logical-mathematical simulation method. They employed formulas, graphs and nomograms from current manuals. Only maneuver to thwart automatic tracking and feinting action required precise calculation. Can one employ such a model as a foundation in drawing up a "strike delivery" plan? This depends on many factors, and particularly on the urgency and importance of the mission. The pilots of a flight going on a training mission which will be graded consider their variant optimal. The other flights, however, also submit their models for appraisal. They may have a different opinion. On the back cover there is a mission model where the wingman also participates in attacking the target, with an S-turn employed to thwart lock-on. There are seven rather than six phases of the mission. The reader, performing the role of commanding officer, can appraise the advantages and drawbacks of each variant and select the optimal variant.

In conclusion one should discuss the expediency and necessity of modeling each mission. One can express the view that in addition to a test or experimental flight, one must model training flights involving penetration of hostile ground or air countermeasures. It would be useful to elaborate models of the stages of a routine flight, where safety measures should be observed particularly rigorously. As was already noted, relatively simple exercises with stable parameters have been examined in advance and run through in the air. Pilots undergoing training can take a copy from the original.

In our case the enemy is only designated; he does not exert any active countermeasures and does not change his positions. Therefore simple methods of constructing a model were employed. If the opponent may unexpectedly create various threatening situations, and his intentions are not clear, one applies the game modeling method, which we shall discuss in the next article. (To be continued)

Types of Game Models

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 5, May 77 signed to press 31 Mar 77 pp 10-11

[Article by Cols V. Babich, A. Dubovitskiy, and Ye. Lavrent'yev: "Games Method"]

[Text] Games models pertain to the third area of application of modeling in military affairs -- analysis of the process of combat. It is expedient here to examine their characteristic, distinctive features and types, sequence of construction, the aims and stages of games modeling.

We shall begin with a description of game models. Bilateral tactical exercises can serve as a vivid example of a model-game. But certain conditions must be maintained in order to consider an exercise an analog of forthcoming combat actions: similarity between the practice situation with actual combat, investigative character of exercise (when certain new modes of conducting combat are elaborated, not already known ones reproduced), as well as the possibility of obtaining new information which can form a basis for practical recommendations. Exercises and actual combat actions without meeting these conditions are viewed as processes which exist independent of one another. This must be considered in describing game models.

Game simulation as a method of cognition of military phenomena applies to the period of initial controlled engagements. The commander has almost always elaborated his decision on the basis of analysis of presumed actions by the opposing sides. In wars of the past, when arms, tactics and organization of troops were comparatively simple, the correctness of a decision would be determined by the commander's talent and experience. As the complexity and scale of combat increased, scientific forecasting and calculations were required.

The principle of game modeling consists in the following: the executor, performing the role of umpire at each stage of the engagement, compares the decisions of the opposing sides and determines the potential result of their actions. Depending on the selected effectiveness criterion, he considers the actions of each fire unit or averages the results by tactical subunits.

Usually variants of an engagement or attack are played out move by move. Move is defined as the advance of an aircraft (group of aircraft) to each subsequent line. The number of lines specified by the executing individual determines the accuracy of the model and the duration of the process of investigation. The "adversary" undertakes a response move to each move taken by the other side. The main distinctive feature of a game model is vigorous actions by the "enemy" in a manner characteristic of him.

There exist several kinds of game modeling: mental (logical), physical, semi-physical, and mathematical.

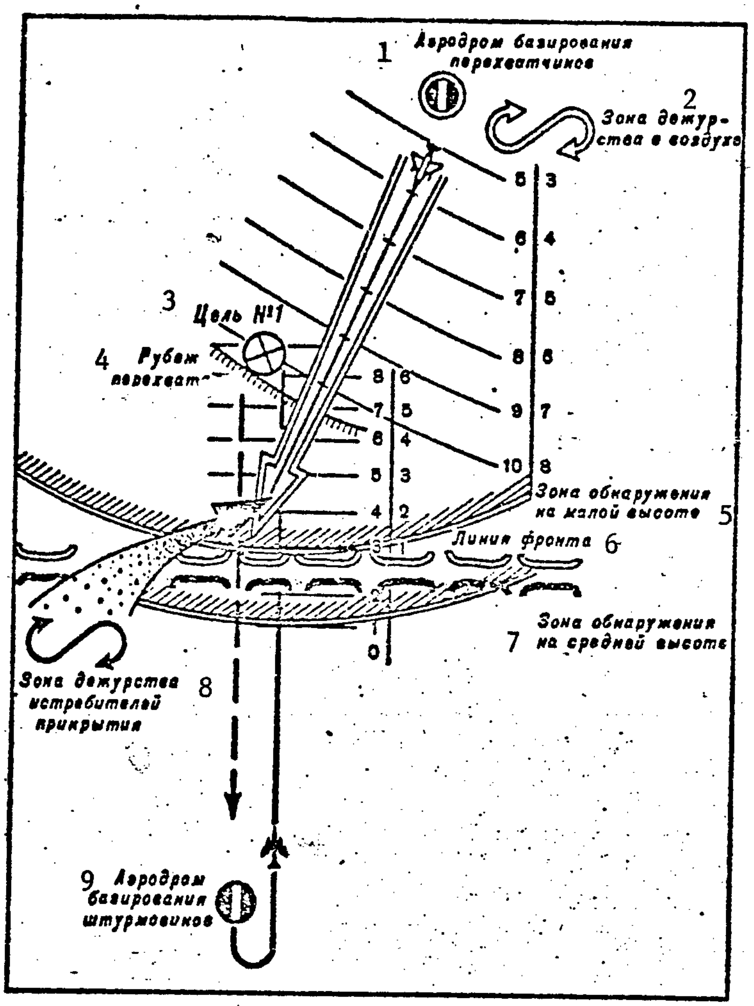
With mental modeling the commander pictures the forthcoming engagement, studies it or performs a mental experiment, after which he transfers results to the actual object. The "opponent's" plan is revealed in the course of such simulation, as well as the layout of his combat formation and modes of conduct of defense (attack), after which the structural plan of action is elaborated. Object models are usually employed in the process of mental modeling of an air engagement or attack -- models of aircraft, targets or overflown terrain as component parts in experiments (methods of mental and physical description of a phenomenon are unified into a single whole).

Physical modeling is an experiment in the air with active countermeasures by a concrete "adversary." Thrice Hero of the Soviet Union Col Gen Avn I. N. Kozhedub writes about such an experiment in his book "Vernost' Otchizne"[Loyalty to the Homeland]. This was a demonstration air engagement between a Soviet Yak with a captured Messerschmitt, a battle in which "the strong and weak points of the aircraft were studied." On the basis of the results of this full-scale simulation, recommendations were given to combat pilots on tactics of combat against specific enemy aircraft.

According to information contained in foreign publications, at the present time the U.S. Air Force has established a squadron of F-106 aircraft which "play" the "enemy." The pilots employ tactics characteristic (in the opinion of their superiors) "of contemporary air warfare." New techniques of action against the "enemy" are recorded and subsequently incorporated into pilot air combat training programs. The actions of North Vietnamese fighters in the recent war in Southeast Asia form the basis of the techniques employed by the pilots of the F-106 squadron.

Semi-fullscale simulation is conducted on ground models, which usually include a fully-functioning aircraft cockpit, a target flight (movement) simulator, and analog-digital computer and a control console for the instructor. An image of the maneuvering air or moving ground target is

projected onto screens situated forward of the cockpit. Elaboration (investigation) of the elements of air combat is performed with two operating cockpit simulators.



Graphic Display of Situation for Game Simulation.

Key to diagram: 1 -- interceptor air base; 2 -- duty zone in air; 3 -- target No 1; 4 -- interception line; 5 -- detection zone at low altitude; 6 -- battle line; 7 -- detection zone at medium altitude; 8 -- duty zone of covering fighters; 9 -- attackers' air base

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Due to the high cost, semiphysical models are employed primarily for the conduct of studies connected with developing new equipment or comparing it with analogous models possessed by the potential adversary.

Mathematical simulation is an expression of the process of combat in the form of systems of equations. The stages of mathematical combat are played out on a computer (the process is called dynamic programming).

Symbol or graphic models can be called, with certain allowances, a representation on paper of the process or results of mental game simulation. Mental and logical-mathematical modeling is becoming quite widespread today in practical flight activities. However, one cannot say that there has been no experience in this area. Analysis of a forthcoming engagement, reflecting the logical process of pilot thinking, was conducted during the Great Patriotic War. The following was stated by Hero of the Soviet Union Maj P. Peskov in an article entitled "The Commander in Combat," published in the newspaper STALINSKIY SOKOL [Stalin Falcon] on 16 April 1943: "The Group commander should do the bulk of combat control work prior to departure. It is necessary to prepare for air combat on the ground. At the moment one is swiftly closing with the adversary, a commander cannot give protracted thought to his tactics and explain it to his men. He has only a few seconds to make his decision and issue orders to his group. Control in combat is complicated by the fact that the commander himself is fighting; it is also complicated by the great space involved, making it impossible to observe all details of the air engagement. Therefore it is necessary thoroughly to cover the enemy's tactics with one's group on the ground, the possible variants which the enemy will employ, all possible instances and circumstances, and to prepare several schemes, so that the pilot will know how to fight under various conditions and what the commander expects of him in combat."

The objective of game simulation is to obtain as much material as possible on the character and probable result of forthcoming combat operations. The tasks of investigation are examined somewhat more broadly than when constructing a flight model. The operating procedure of the executing personnel can be presented as follows: information stage, selection of criteria, graphic presentation of the situation and its analysis, playing out the engagement stage by stage, and selection of the optimal solution.

We shall examine the process of game simulation with a concrete example. We shall state at the outset that the proposed method is not the only one; it merely reflects certain experience in this area.

We shall designate the opposing sides "Brown" and "Blue." The "Brown" consists of subunits of ground-attack aircraft and fighter cover, and the "Blue" -- an interceptor subunit. The mission of the ground-attack aircraft is to attack target No 1, the mission of the covering fighters -- to fight off attacks by "hostile" aircraft, while the mission of the interceptors is to prevent the strike by the ground-attack aircraft. We shall emphasize one of the fundamental conditions of the study: executing personnel (the working group) takes a strictly neutral position in regard to the "adversaries." Only with an objective assessment of the capabilities of the opposing sides can one hope for reliability in a game model.

The information stage proceeds as follows. First known data on the "adversaries" are systematized: basing, composition, degree of preparedness, principles of tactical employment, and combat characteristics. Then an appraisal is made of the external conditions which will be introduced into the model: weather, topography, time of day, navigation situation.

One should bear in mind that a ground-attack mission can be modeled only with the availability of data on the "enemy" air defense system which they must penetrate. It is essential that this information be valid at the time of the strike. Thus the information needed for simulation should include data on the combat capabilities of the opposing sides, characteristics of external conditions, and intelligence on the "adversary" on a real-time basis.

Effectiveness criteria are then selected. At this stage one defines the concrete investigation aims and methods of achieving them. The greater the number of objectives, the more complex the process of simulation and the less reliable its result. It is always better to reflect in a model the most important aspects and relationships of the target phenomenon. If ground-attack aircraft have been assigned the mission of destroying a ground installation and to avoid sustaining losses, one criterion (destroying the target, for example) is taken as the main criterion in calculations. In our case, for simplicity of presentation, we shall not introduce the criterion of damage. The main task for the "Brown" is to penetrate through to the target and to avoid taking losses, while the main task for the "Blue" is to intercept them at the specified line.

As a result of modeling, we should obtain a graphic picture of the attack mission, suitable for our study. Investigation results form the basis of the decision by the commander of the "Brown." Also assisting the executing personnel are reference and auxiliary materials available in the tactical classroom. Calculations are performed on the basis of simple formulas.

At the following stage the situation is graphically depicted. Executing personnel places on a clean sheet of paper, at the selected scale of distances, airfields and air duty zones, the battle line, the "Blue" automatic radar tracking and detection zones, air defense weapon killing zones, and intercept lines for various degrees of readiness.

Based on the problem solving conditions, the "Blue" interceptors are on the ground on an alert status or scramble to their assigned area when the alert is sounded. A line indicating their possible track is run from the field and zone to the intercept point, broken down into one-minute segments. The count includes passive time expended on takeoff, climbout and turn to the target intercept course.

The flight path of the attacking "Brown" aircraft is plotted using the above-described method. It is divided into one-minute segments from the "Blue" radar detection line to crossing of that line on the return flight.

The situation analysis shows that the attacking aircraft can deliver the strike in the sixth minute (see figure) after entering the "Blue" radar detection zone when flying at low altitude, and in the eighth minute when flying at medium altitude (in this instance the detection line is closer to the airfield of the attacking aircraft, and additional time is expended on maneuver).

The "Blue" interceptors appear at the point of potential intercept in the 10th minute after takeoff and in the 8th minute after departure from the airborne alert zone. Consequently the attacking aircraft can avoid encountering "hostile" interceptors prior to reaching the target only if they employ the "low-altitude" variant.

The stage-by-stage game is conducted further. A game of chess can serve as an analog to the playing out of possible actions by the opposing sides. It is sufficient to determine what each of the opponents is thinking before each move. In our case each move is movement by the "adversaries" along the next minute segment. The game result indicates that if the "Blue" interceptors are late in engaging at the calculated point but do not decide not to pursue the attacking aircraft, the encounter may occur above the battle line. This circumstance is the principal one for selection of tactics for the "Blue" covering fighters.

The "Brown" decision. The attacking aircraft fly to the target at low altitude and attack without preliminary maneuver. There is no time for additional maneuver over the target. At the moment the attacking aircraft enter "hostile" territory, the covering fighters take position in a zone situated by the "Blue" radar detection line. The situation does not require direct escort to the target area. Is this variant optimal? The model must answer this question. The model can be interrogated with questions pertaining to solving the problem based on selected criteria: what is the mutual positioning of "Brown" and "Blue" aircraft at the present moment? What will happen if the "Brown" is delayed or the "adversary" proves to be more mobile than had been assumed? What influence on the situation will be exerted by displacement of the air duty zones of the "Brown" fighters or "Blue" interceptors? Under what circumstances is direct escort of the attacking aircraft or clearing of airspace (establishment of a screen in the target area) necessary?

Thus at this stage one can examine the properties of the target phenomenon on a model, imposing certain restrictions. We emphasize that the decision was made by the "Brown" on the basis of the results of physical simulation. It differs from solutions, which in operations research are defined as quantitative assessments obtained as a result of analysis of mathematical models. The effectiveness of simulation (using a simplified method) is evaluated on the basis of how it assists the commander and pilot in selecting an optimal action variant, whether it is accessible in a realistic working situation, and whether the adopted solution is optimal according to the basic parameters. (To be continued)

Similar Analog Model

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 6, Jun 77 signed to press 29 Apr 77 pp 16-18

[Article by Cols V. Babich, A. Dubovitskiy, and Ye. Lavrent'yev: "Analysis, Playthrough, Plan"]
[Text] Under all conditions it is believed that elaboration of a physical analog is a first and mandatory stage in simulating a flight mission. One

can construct a mathematical model only after selection and formulation of the physical characteristics of the object, that is, examination (discussion) of a physical model. In this article we shall examine the example of construction of a model by a similar analog, as well as the indicators of reliability (realisticness) of a model, and some rules of examination with this method.

The composition of forces and combat capabilities of the adversary have not changed: the "Brown" force has ground-level attack aircraft and fighters, while the "Blue" has interceptors. The "Brown" has been given a new mission. Its fighters are to challenge the "Blue" interceptors to combat and inflict the heaviest possible losses in the air.

Inasmuch as the "Brown" side already possesses some experience in modeling, we can include a point on analog selection in the information stage. In other words it has become possible to seek a ready model which corresponds to the situation and which has undergone practical testing.

The criteria on the basis of which optimization is performed will be an attack against hostile aircraft, with the element of surprise, and no friendly losses. The first criterion is the principal one.

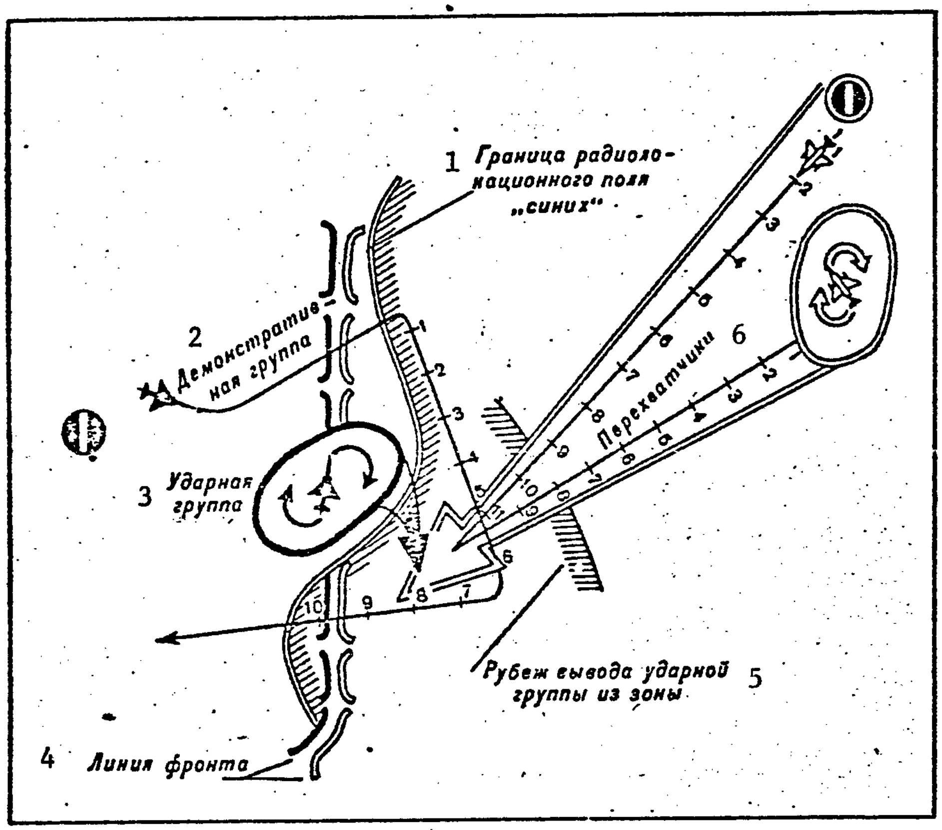
At the information stage the executing individual comes to the conclusion that he can take as a basis of examination an attack model elaborated previously (see article "Searching for a Better Variant," AVIATSIYA I KOSMONAVTIKA, No 4, 1977). Since the attacking aircraft successfully mounted the strike and were not attacked by enemy interceptors, they can be assigned the role of diversionary group. The cover fighters become the attack group. The roles are changed, but not the sequence of mission execution. This means (to certain limits) that the previously-performed calculations are also valid.

The basic plan is to scramble the "Blue" interceptors against the diversionary group, drawing them off in pursuit into a designated area, subsequently mounting a surprise attack from beyond the "enemy" radar-covered area.

In order to ensure the safety of the ground-attack aircraft, their depth of penetration into enemy airspace can be reduced. The time safety factor excluding a confrontation with the "Blue" interceptors is determined as a result of playing out the variants stage by stage. Following graphic situation display and determination of gaps in the "enemy" radar observation zone, the location of the air ambush is selected. A line is designated, after crossing of which by the "Blue" interceptors the "Brown" fighters are engaged. Information on crossing of the line comes by radio from a ground control facility or from the leader of the diversionary group.

The playout of the variants gives reason to assume that if events develop according to the "Brown" plan, the "enemy" interceptors will enter the

ambush and will be attacked with the element of surprise. The fighters will enter deliberate combat, which will begin with a specified arrangement of forces in the air. The situation will make it possible to dictate terms to the "adversary" and will ensure seizure of the initiative. Achievement of success should also be promoted by a programmed element of surprise. The "Brown" decision is based on an optimal engagement variant selected in the course of playing out the mission (see figure). The plan specifies when the count begins, the procedure of control and maintenance of continuous coordinated action between the diversionary and attack groups. When necessary a reserve is designated (a group to build up the attack effort).



Graphic Situation Portrayal for Playing Out Deliberate Engagement of Fighter Attack Group

Key to diagram: 1 -- boundary of "Blue" radar-covered area; 2 -- diversionary group; 3 -- attack group; 4 -- battle line; 5 -- line of withdrawal of attack group from zone; 6 -- interceptors

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A ready model taken from the library suggested the employment of a new device. Examination was significantly facilitated thereby, by shifting certain details. The attack model proved useful in elaborating a model of engagement. If conditions were changed, however, such as a ground target displaced deeper into enemy territory, the attack model would be of a

An inaccuracy can be revealed, for example, in the following determination of target: "Execute a decoy (feinting) maneuver." In actual fact this is not one but two maneuvers, different in content. In tactics a "decoy" is an attempt to compel the adversary to concentrate his forces on a phony axis of attack. A feinting or diversionary maneuver is performed with the objective merely of diverting the adversary's attention from the selected direction of attack. A similar lack of clarity arises with the following specification: "Breach (surmount) target objective air defense." "Breach," states the dictionary of military terminology, is a vigorous, decisive mode of penetrating a deeply-echeloned enemy defense, breaking through it with the aim of subsequently putting the main forces into the resulting breach. Surmount is a more general term which, in addition to such methods as breaching, also includes bypassing lethal areas, undetected "infiltration" by aircraft deep into enemy territory and evasion of antiaircraft fire. In the one instance the method is based on fire neutralization, and in the other -- preservation of invulnerability, concealment to gain the element of offensive surprise.

Thus to model penetration or bypassing of a danger area is not one and the same thing. In like measure, uncertainty can be introduced (directing modeling along an incorrect path), such as excessively general determination of the objective, and imprecise use of tactical terminology.

We shall now discuss adequacy of information. Cybernetics provides a precise (for modeling) definition of information: "Information is all that which eliminates uncertainty." Analyzing available information, the executing individual should observe the principle of adequacy. Depending on the quantity (completeness) of data, information contains more greater or smaller details on the air situation, but cannot be its absolute expression. An all-encompassing situation picture is not required for modeling concrete tactical devices. The degree of detailing should correspond to the conditions of mission execution. Consideration of unnecessary or secondary factors will only complicate the process of modeling and will not affect the end result.

Also of considerable significance is the adopted level of synthesis. In analyzing a weather report, for example, instability of the weather requires that it be averaged. The same can be said about the expected intensity of jamming, or uninterrupted control from the ground. In selecting a mode of action, preference is given to objective information based on facts.

Processing of available input data can be broken down into three stages: analysis of suitability of information for solving the specific problem, synthesis of secondary data and detailing of requisite data for simulation. The executing individual should be convinced of the adequacy of the necessary data and should obtain lacking data. A list of required initial materials and information sources for constructing standard models can order and simplify this process.

And now a few words on utilization of information models. This signifies that one should do less calculating and take more information from graphs

totally different form and could not assist the executing individual. Thus it is once again confirmed that simulation is always based on experience but requires constant innovation.

What is the reliability of a game model? The correctness of conclusions obtained as a result of examination of game models depends on the completeness and genuineness of data on the adversary. One of the fundamental rules of game modeling is consideration first and foremost of the opponent's strong points, followed by search for weak points. The skill of the executing individual consists in revealing the opponent's concept, his possible plan of action, not forcing him to make moves advantageous to his opponent. To construct a game model of the chess game type means to suffer failure in advance. The opponent is a grand master who will not be inclined to repeat the moves of the game he played on the previous day.

It is also necessary to note that game models make it possible to transfer to an actual object (any tactical device at two-sided exercises) far from all conclusions, since they do not fully reflect the complexity of the forthcoming events. Of the greatest value are results pertaining to specific, precisely formulated tasks, such as one-on-one (and sometimes group) air combat with a specific opponent or an attack on a ground installation the antiaircraft defense system of which is known in advance.

In the process of modeling it is desirable to observe certain rules, which can be formulated as follows: clarity of the problem, concreteness of the objective, adequacy of information, utilization of information models, prevention of repetitions.

Let us examine each of these in greater detail. We shall begin with the first -- clarity of the problem. The tactical problem should be stated to commanders in such a manner that not much time is required to think it over, but they can immediately proceed to examine the problem. Brevity and preciseness of the assignment determines correct selection of an analog and auxiliary material for calculations. In addition, conditions are created for balanced logical deliberations (construction of a mental model). Lack of clarity at the outset of the modeling process can involve first and foremost ignorance by the executing individual of the composition of forces involved in performing the air mission, and the situation at the beginning of combat operations. The mission, worded approximately in the form "destroy the enemy, fighting bravely and resolutely," cannot serve as a basis for construction of a game model.

Concreteness of objective is also essential. Precise determination of the concept and objective of the engagement (attack) determines the completeness and correctness of conclusions (results of modeling). The executing individual should have a clear picture of what is to be achieved with employment of the variant he is elaborating. For example, penetrate to the objective without detection, attack as quickly as possible, seal off the airfield, construct an efficient combat formation, etc. Streamlined formulas are inadmissible here, and inaccuracies are dangerous.

and nomograms. It is true that this principle requires an adequate quantity of requisite materials. They should be simple to use, such as the navigator's plotter, where bank radius and time are determined in seconds. Considerable possibilities for combat simulation will be found if the same method is used to determine the level of energy based on known magnitudes of its components (or other data influencing the attainment of tactical superiority). At first it is not mandatory to count meters, seconds and degrees. It is sufficient to determine "larger" or "smaller" in a comparison in order to determine a standard of behavior in combat.

Standard models calculated with the aid of a computer, which are used as a model in calculations, can be useful. At one time intercept models constituted a reliable basis in forming new techniques. As is indicated by the experience of local wars, many types of antimissile maneuver -- S-turn, alternate passing, fanning out -- were elaborated on the basis of similar maneuvers against antiaircraft artillery, employed in the era of piston aircraft.

Finally, elimination of repetitions. This principle presumes possession and practical utilization in practical modeling of air-tested models of engagements or separate tactical devices. It is necessary to commit to memory not only successful but also unsuccessful devices. The following question immediately arises: there are very many devices, and an entire library will be required to store them. An answer can be provided by anybody who attempts to weigh his tactical baggage and inventory it. A perusal of a library of models will not always permit selection of a complete analog, but one can copy individual elements. In addition, the way is opened up to study modern tactics and to establish new and effective devices.

A successful device is usually repeated until it ends its usefulness. Failure serves as a warning for the future.

The Americans in Vietnam, for example, installed new low-power jamming transmitters on board their tactical aircraft and constructed a model of a close-packed combat formation. They were counting on effectively protecting their aircraft with active jamming. As a result some antiaircraft missiles missed, but those which did hit the target brought two aircraft down at once. The technique was discarded, and intervals and spacings between aircraft were once again increased.

According to reports in U.S. publications, it has also been necessary to abandon the so-called "sudden appearance" method, which was played out on numerous occasions under practice area conditions and promised a high degree of invulnerability to the attacking aircraft. It consisted essentially in the following: the attacking aircraft would approach at treetop level to the inner boundary of the antiaircraft system killing zone, upon which it would execute a steep vertical bomb delivery maneuver -- "an over-the-shoulder turn." That airspace not covered by missile fire, however, proved to be covered by antiaircraft artillery. An aircraft which did not

rapidly change its angular position relative to the battery would come under fire. This variant was not considered in the process of modeling, and as a result the model was kept in storage in order to avoid repeating it.

Some models of combat maneuvers in local wars have not been given unequivocal assessment, although they have passed the test of fire. This applies to the deliberate separation of flight leader and wingman in a two-aircraft flight in the process of maneuver combat. Standard and tested maneuvers under the names "defensive split," "hard turn," "scissors" and others have produced the anticipated result only with planned actions by the adversary. If the adversary's response maneuver or countermaneuver was illogical, a so-called critical situation would develop. Analysis of such situations indicated deficiencies in the equipment (aircraft) or poor training of the pilot.

One example of a technique elaborated by methods of mathematical and physical modeling is a maneuver to evade a surface-to-air missile which was utilized by U.S. pilots in the air war in Vietnam. Initially the converging flight paths of aircraft and missile would be calculated mathematically, after which evasion variants were practically tested (physical model). There were three principal variants: a vigorous turn toward the missile with a subsequent dive or pitchup, a rollout, and carrythrough beyond the potential attack target. According to calculations, the optimal distance at which to initiate the turn was 5-7 km.

Experience indicates that the "situation analysis at 1300" method is unsuited for modeling combat. The search for optimal variants involves creating mobile situations in a limited airspace. The attack is simulated above a model of the practice range or target location area, and examination with a graphic analog -- marked-out flight paths, is effected by moving the pencil by minute segments, making intermediate decisions. The logic of the forthcoming combat is born is movement, in a dynamic situation, the direction of the main attack is chosen, and each maneuver is substantiated. It is difficult to write all this down on paper, particularly in mathematical form, but it can be constructed. The pilot can be assisted in this by simple simulation methods.

The main advantage of game modeling in our opinion is elucidation of the most effective technique and mode of action with a specific disposition of enemy forces, the possibility of predicting the result of an engagement (attack), as well as determination, on the basis of comparison of the anticipated attained result, of ways to achieve further improvement of tactics. (To be continued)

Mathematical Logic Method

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 7, Jul 77 signed to press 31 May 77 pp 10-11

[Article by Cols V. Babich and A. Dubovitskiy: "Logical-Mathematical Method"]

[Text] This article deals with the possibilities of the mathematical logic method in simulating air combat. We shall examine two items: the requisite level of training of the executing individual, and the stages and result of modeling.

In order to obtain positive results it is necessary to employ the data of combat experience, knowledge of one's weapon and the ability to master it, and also to take into consideration the combat capabilities and tactics of the "opponent." Of importance thereby is the ability to analyze and to think logically. It is essential in view of the limited nature of input data for calculating quantitative characteristics (probability of intercepting, downing the adversary, etc) in preparaing for a mission.

As is indicated by past experience, each generation of fighters has left behind a generalized model of air combat, which comprised the basis for examination in forming new tactics applied to new aircraft. The experience of the Great Patriotic War is particularly valuable under present-day conditions. The traditions of the glorious Soviet aces are grounded in the principles of contemporary air combat, demands on combat formations, methods of achieving tactical superiority in combat, and the moral-political training of pilots.

Aggressive character, close coordination between aircrews (groups), the element of surprise, a skillful combination of maneuver and fire, intelligent operation of one's aircraft, initiative and constant improvement of tactical devices were considered basic principles of air combat in the last war.

The following demands were made on a combat formation of fighters: freedom of maneuver, securement of 360° search, mutual fire support, capability of rapid re-formation, concentration of efforts on the axis of attack, precise and continuous control, maximum concealment.

"Altitude-speed-maneuver-fire" is the well-known formula for combat by A. I. Pokryshkin. It pointed out ways to attain victory and could be considered a unique and expressive model, on the basis of which concrete plans of an offensive air engagement were put together. The plans proper were born in the course of running through the mission on the ground and constituted detailed optimal variants of forthcoming actions in the air. A book entitled "Taktika istrebitel'noy aviatsii" [Fighter Aviation Tactics], written just after the war on the basis of an analysis of combat experience, stated: "Following are the basic elements of the plan: the combat objective (resolute annihilation of the adversary or stopping of an enemy

attack), the combat concept, the methods by which tactical superiority over the adversary is achieved, distribution of forces by stages of combat (change in combat formation), principal direction of attack, methods of control and coordinated action. The combat plan, in the form of a presumable variant (sometimes several variants), is elaborated on the ground, refined in the air after obtaining initial data on the adversary, and is finally adopted when the fighters spot hostile aircraft en route. Necessary changes, which are dictated by the situation, can be introduced into the plan when closing with them, and also during combat."

War veterans claim that experienced commanders, studying the situation, would create a mental picture of the forthcoming engagement and specify the surest ways to accomplish the assigned mission. Pilots who carefully prepared for each mission also approached this level. Supported by their knowledge of combat experience, they would draw an analogy with an engagement which had taken place in a similar situation and would use it as a model. It was taken into consideration thereby that there was never a total similarity and that the new engagement would have its own unique features. Therefore the analogy method proper was never confused with mental processes or conclusions based on them. The ability to select the most suitable variant from a number of known variants was considered a valuable quality, which created conditions for making an optimal decision.

It is appropriate in this connection to quote from the book "Istrebitel'naya aviatsiya v Otechestvennoy voyne" [Fighter Aviation in the Patriotic War]. It states: "A most important condition for successful combat and achievement of close coordination was study on the ground of different attack variants which determine in advance pilot actions, such as when encountering a single reconnaissance aircraft, a group of bombers, a pair of fighters approaching high or low at various angles, etc. All new variants would be elaborated in conformity with enemy aircraft types and the concrete situation conditions. Prior preparation with this method enabled the pilot quickly to reach the most correct decision in combat."

This method was then called "advance preparation for combat." Today it would be called modeling. We shall note that this method of preparation was actively employed at the front under conditions of an acute shortage of time and without computers.

Referring to the experience of the Great Patriotic War helped find answers to questions about the objective, methods and results of modeling air combat. Objective: quickly reach the most correct decisions in combat. Methods: elaboration of an optimal variant (several variants) in the course of running through the mission on the ground. Results (simulation output): plan of the forthcoming engagement.

Combat modeling includes all stages of construction of a game model. At the information stage the pilot selects from the entire set of available and incoming information on the adversary the input data requisite for modeling. He should not experience a shortage of information, for in the final analysis

information will determine the realisticness of the model. At the same time inclusion of a large quantity of data in the process will only make the study more difficult and will not appreciably influence the result. For example, in modeling close combat it will definitely be necessary to have performance data on weapons, aircraft power and maneuverability, while an intercept model cannot be prepared without speed and altitude data. Essential for other types of combat are other but always concrete and sparse data.

The following factors, which directly affect the course and outcome of air combat, must be considered: pilot, aircraft, armament, electronics, control system. They are often called "components of success," alongside the correlation of forces of the opposing sides. Experience indicated that if one side achieved superiority in all components, it could be considered the probable victor even before combat was joined (if the morale factor and random occurrences were ignored). This meant that pilots had greater fire and tactical capability, aircraft with better performance and equipment, making it possible to detect and lock onto the target at greater range. In addition, a flawlessly-operating warning system would beat the adversary in providing information to friendly fighters on the air situation.

With these advantages the adversary could achieve success only by achieving total surprise or by employing a new tactical device against which effective countermeasures had not been developed. We must note that superiority was rarely observed in all specified indices in large-scale conflicts. In the Great Patriotic War air engagements (at least the majority) were waged by fighter aircraft of approximately the same type but with differing performance characteristics (the Yak-3 and the Me-109, for example). The same can be said about the wars in Korea, Indochina, the Near East, where air combat involved either subsonic jet or supersonic fighters with approximately the same armament and equipment. A dissimilarity could be determined only with a precise comparison of detection range of on-board radars, killing radius and pilot capability. Comparison would sometimes take place in the air in the process of experimentation or, as it is now called, full-scale physical modeling.

In 1942, for example, the Scientific Research Institute of the Air Force conducted an experiment with the participation of a Soviet Yak-1 fighter and a captured Me-109. A series of test air engagements were conducted, the objective of which was to determine effective maneuvers based on revealed weak points of the enemy aircraft. The results of the experiment, in the form of recommendations on tactics of combat with the Messerschmitt, were sent out to all active units. Optimal variants were put together in conformity with the recommendations, on the basis of which the plan of a forthcoming engagement would be elaborated.

In proceeding with modeling, the pilot usually had results of comparison and recommendations on combat with a concrete adversary. In addition, methods manuals always contained models of standard attacks, defensive maneuvers and tactics. In most cases the pilot had to put together a

combination of these or select a variant corresponding to the situation. However, there was constant search for new innovations, since in time the enemy would determine the secrets of our tactics and would himself attempt to avoid predictable repetition. Equipment and weapons were upgraded in the course of the war, and old methods of combat employment would prove unsuitable.

Considerations of logic were essential in the course of running through an engagement in advance, and in determining each sequential move by the adversary. Here the pilot had to be able skillfully to utilize available comparison data and to perform the requisite calculations in order to draw correct conclusions. Logic was combined with mathematics. In other words, it was necessary in combat fully to utilize one's strong points and to conceal weaknesses from the adversary.

The experience of past wars (including recent conflicts) indicates that most frequently the adversaries had different altitude capabilities as well as differences in power and maneuverability, with other indices approximately equal. Superiority in thrust to weight was characterized by a great surplus of thrust, making it possible to climb faster. Better maneuverability was achieved by lower wing loading and provided considerable horizontal trajectory curvature.

Following is an excerpt from recommendations on utilization of fighters in combat against fascist aircraft (distributed to all regiments during the Great Patriotic War). "4. A comparison of the specifications and performance of our new aircraft with the Me-109 shows the following: a) the armament on our aircraft is more powerful; b) our Yak-1 has greater speed, equal rate of climb and better horizontal maneuver capability at altitudes above 3,000 meters. At lower altitudes the Me-109 has superior maneuverability and rate of climb." Also contained were data on climb during a combat turn and altitude loss during a roll, bank time and radius, times various altitudes are reached, armament specifications and most advantageous maneuvers.

The pilot needed precisely such information on the enemy (rather than weight, dimensions, type of powerplant, etc) for a comparative analysis and elaboration of combat tactics. It was recommended "that the adversary be drawn to a disadvantageous altitude by a combat formation echelonment in which the group engages, while the covering group continuously attacks the adversary vertically. It would be a gross error to transition to horizontal maneuvering immediately following the first pass. The initial altitude advantage should be maintained during the entire engagement and be expended very economically."

It is characteristic that approximately the same situation developed in air combat in Korea between the MiG-15, flown by pilots of the Democratic People's Republic of Korea, and American Saber jets (Fokhter: "Vozdushnyye voyny" [Air Wars], Moscow, Voyenizdat, 1957). As was noted in foreign publications, in the war in Indochina North Vietnamese pilots developed their tactics taking into account the excellent maneuverability of their

aircraft (lower wing loading with equal thrust to weight) and better high-altitude performance characteristics. A comparison of the numerical composition of the sides participating in combat (the adversary had considerably more aircraft) indicated the necessity of selecting in tactics the principles of surprise and economical expenditure of forces. Attacks were to be delivered at the enemy's most vulnerable spot. Taken into consideration thereby were not only the vulnerable points on the aircraft and weaknesses of the weapons, but also deficiencies in ground control, the rigidness of the combat formation and the poor psychological preparation of aircrews.

We must also discuss another matter. In order to model air combat, essentially a highly complex phenomenon, it was necessary to know the laws and patterns of its development and to take into consideration new conditions and factors influencing choice of tactics. An analysis indicates that the role of the principal elements of combat -- maneuver and fire -- gradually changed. Maneuver occupied an increasingly subordinated status in relation to fire and was considered merely a technique supporting initiation of the attack. With the appearance of air-to-air missiles as fighter armament, the term "strike" began to be adopted -- a combination of fire with forward movement by one of the groups of aircraft or the entire combat formation. In constructing his model the executing individual took into consideration that the main element in the strike is the moment it is delivered and the direction of the salvo. The strike or attack usually determined the outcome of the engagement, and therefore it was painstakingly planned (played through) and supported with auxiliary forces.

Combat formations began to detach as aircraft became faster and more potent. The squadron commander received certain independence in performing tactical missions, as did subsequently the flight leader and, finally, the leader of a two-aircraft flight. This means that an increasingly broad group of flight personnel are being involved in modeling combat. Practically every pilot elaborates a mission plan, where the "adversary" will be encountered, on the basis of an optimal variant selected from several possible variants.

The space occupied by combat is also steadily increasing. This limits the group commander in monitoring the actions of his men but does not eliminate continuity in controlling them. A ground command post is exerting increasing influence on the course and outcome of air combat. For example, not only pilots but also the control facility team took part in combat in Vietnam and in the Near East; the control facility team monitored the air situation by radar and informed the pilots of situation changes. Frequently the command post would determine the moment and direction of attack. Thus there was an increase in the number of elements which had to be considered and compared in the modeling process.

Laws and patterns of development of combat also include a steady increase in the pace of combat and succession of events. Less and less time is available for thinking through the next move, but the mental process proper is not diminished. It is transferred to the ground, to the classroom,

where in a calm environment the pilot can solve many tactical problems and choose optimal variants for various conditions.

Thus the comparative analysis performed at the initial stage of modeling can be called a process of information-calculation and logical-analytical (creative) activity on the part of the pilot (commander). The content of and conclusion from the analysis would be organically incorporated into subsequent stages and influenced by them. (To be continued)

Air Combat Tactics

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 8, Aug 77 signed to press 1 Jul 77 pp 20-23

[Article by Cols V. Babich and A. Dubovitskiy: "Shaping the Tactics of Combat"]

[Text] The basic content of the information stage in modeling air combat is a comparison of the forces and combat capabilities of the opposing sides, as well as estimate of the current situation. The specifics of the work performance by the executing individual at the two subsequent stages -- selection of criteria and graphic representation of the situation -- has been fairly completely presented in an article entitled "Games Method" (AVIATSIYA I KOSMONAVTIKA, No 5, 1977). We shall now discuss stage-by-stage playing through the engagement and selection of an optimal solution.

It is expedient to play out a mission stage by stage as follows. Dividing the entire engagement into stages, the executing individual determines what the main element at each stage is, and then in the process of closing movement by the opponents, move by move, he selects the method of achieving the intermediate and end objectives of the engagement.

Approach has always been considered the first stage of any air engagement. The main thing on the approach is establishment of conditions for an attack with the element of surprise. This is confirmed by the experience of the Great Patriotic War, where three fourths of all enemy aircraft shot down in combat were hit on the first pass. The element of surprise was a result of the highly-developed tactical thinking of the pilot (commander) and was achieved by skillful utilization of such factors as concealment, observance of concealment measures, military cunning, and constant renewal of the techniques and methods of combat. An unexpected attack frequently stunned the adversary, made him unable to offer vigorous resistance, and decided the outcome of the battle at the first stage. Frequently success was achieved with enemy numerical superiority in the air. Even under present-day conditions this was graphically demonstrated by North Vietnamese pilots in the war in Indochina, who won victory in air battles against a numerically superior adversary.

The search for ways to gain the element of surprise would be carried out in the course of detailed assessment of the air situation long before combat was joined (i n our case at the information stage). Analysis indicated

what method (feinting maneuver, deceiving the enemy, decoy actions, etc) is most acceptable for the specifically occurring conditions. In local wars one of the adversaries at times counted solely on the element of surprise and on the result of the first pass. If it failed, the attacking aircraft would break off entirely.

When concealment was placed in doubt (for example, combat was to take place in an area with hostile radar coverage), accumulation of energy by means of a rapid speed increase was considered a most important element in the approach. At this stage the advantage was obtained by the aircraft with the better acceleration capability (a better thrust-to-weight ratio).

The level of energy can be expressed as the sum of an aircraft's potential and kinetic energy. Potential energy is directly proportional to altitude. Kinetic energy can be defined as a certain fictitious altitude which an aircraft reaches at the cost of a total loss of speed. The sum of these altitudes constitutes the level of energy which the pilot can transform into tactical advantage. The value of speed on approach can be demonstrated with the following example.

While executing a steep climb, an aircraft is able to gain 370 meters in altitude from an initial speed of 700 km/h with a loss of 10% of that speed on top. Under these same conditions an aircraft will gain 740 meters with an initial speed of 1,000 km/h, that is, twice as much. As was noted, in three cases out of four air combat ended in the first stage -- after the first successful pass. If the adversary succeeded in responding promptly and undertaking defensive measures, the maneuver stage would begin, where each of the opponents would seek to enter the mobile area of possible weapons employment. Superiority in angular speed of turn was considered the principal element at this stage. A so-called extended advantage went to the aircraft with a light wing loading, with a smaller radius and stabilized turn time. The aircraft with the greater thrust-to-weight ratio, however, could exceed the more maneuverable aircraft in transitional turning speed by extinguishing a portion of surplus energy.

Forced turns (with a high G-load and deceleration) would usually be executed to an angle of not more than 270° in order to enter the potential attack (permitted fire) area as fast as possible or to evade attack passes when the adversary was spotted at weapons employment range. Forcing conditions involved loss of energy, which subsequently was difficult to accumulate. Therefore the pilot precisely selected the moment of deceleration in order to eliminate the threat of being shot down or to reach the firing point more rapidly.

We have examined an example of the influence of advantage in speed on altitude gain capabilities. Now we shall see how speed (level of energy) influences attainment of a position advantage in the course of maneuvering (see figure on back cover).

The adversaries spotted each other simultaneously. Maintaining identical altitude and speed, they began to close. As the aircraft close on one another, the pilot of the aircraft with the higher thrust-to-weight ratio will have a higher energy level due to more rapid acceleration. However, in the process of maneuvering, he will be on the outside of the turn in relation to his adversary if he utilizes steady-state speed and G-load conditions. In order to reach the potential attack area he must get inside the turn or fall back and reduce the angle. He can achieve this only by means of deceleration and increasing the angular speed of turn; otherwise the adversary's position will be more advantageous. Here logic is bolstered by calculations.

Let us assume that at the initiation of maneuver the first aircraft has reached a speed of M=1.5, and its adversary -- only M=0.8. The pilots know that the greatest angular speed of a steady-state turn, independent of the type of aircraft, lies within the range M=0.8±0.2. Therefore the first aircraft enters this range with deceleration, and the latter without changing conditions. Possessing excess speed, the first aircraft expends it to increase the angular speed of turn (creates a G-load close to maximum, increases drag) and turns 270° by the moment it enters the range M=0.8, while the second aircraft, maintaining its speed, turns only 180°. The gain in direction change is 90°. Thus favorable conditions were created for entering the potential attack area. However, failure to utilize this situation to deliver ordnance deprives the first pilot of a position advantage in continuing maneuver. Subsequently he will be compelled once again to straighten his trajectory and expend time to accelerate to the requisite speed (if the aircraft's wing loading is greater).

Thus to the main criterion at the second stage -- advantage in angular speed of turn -- one should add intelligent expenditure of the aircraft's energy. The experience of actual combat indicates that the endeavor to enter the speed range corresponding to optimal maneuverability (M=0.8±0.2) led to a constant decrease in altitude and speed. Whoever decelerated unintelligently, endeavoring to turn faster than the adversary at an inappropriate moment, would gradually lose the capability to attack and would be compelled to defend himself.

In our example the surplus speed of one of the adversaries was sufficient to reach the boundary of the potential attack area. But at that moment energy levels were equal. What subsequent move will be most advisable for the adversary? Readers who wish to continue combat modeling may solve this problem.

At the third stage -- during the adversary's attack pass -- the main criterion can be selected in relation to type of weapon, area of its potential employment, and number of points of fire delivery on the aircraft. Evidently the pilot needs most of all accuracy and swiftness, that is, qualities acquired through persistent labor and drill.

At the fourth stage -- in the process of disengagement, the main thing is not to lose momentum, plus vigilance.

We must state that increasingly less room remains for logical deliberations in modeling the third and fourth stages. The pilot can adhere to several elaborated and well-assimilated variants. For example, cannon fire could be effective only with observance of specified rigid conditions regarding range and angle of approach. Elaboration of many methods differing from one another was not required. Some adjustments were made to this point by the experience of the war in Vietnam, where fighters employed in combat both cannon and guided missiles. Nevertheless even in Vietnam an attack could be effective only from the rear quarter and from strictly-limited ranges.

We should note that the number of stages in the air engagement was selected taking into consideration the experience of past wars. The executing individual can increase or decrease them in conformity with the assigned mission, level of training and available time. The model will not be more reliable if one increases the number of moves in the preliminary run-through, but the pilot will be prepared to respond correctly to more frequent situation changes.

Forecasting of the enemy's actions is based on the assumption that he will not be able to perform those maneuvers (devices) which are disadvantageous to him under the existing conditions. One can hardly expect that, inferior in thrust-to-weight ratio (rate of climb), he will exit from the pass with a climbing maneuver. However, an adversary's "illogical" move in the air has frequently compelled one to ponder the matter, where it was necessary to act. But it was no simple matter to go ahead with some doubtful experiment without preparation on the ground.

Arbitrarily separating logic and mathematics in our method of investigation, we shall note that logic predominates at the first stage, after which it merges with mathematics. This does not mean that the pilot will be performing complex calculations. He should skillfully utilize available reference material in order quickly to select the optimal combat maneuver type and conditions. This is discussed in a fair amount of detail in articles by Engr-Col V. Taranenko entitled "Optimal Maneuvers" (AVIATSIYA I KOSMONAVTIKA, Nos 5, 6, 7, 1977).

Establishment of the combat formation, which begins long before the approach, is eliminated from these stages. We shall note at this point that correct placement of forces prior to an engagement determined its outcome to a great extent. However, with improvement of radar means of detecting air targets, it was becoming increasingly more difficult to conceal the combat formation (and consequently to achieve the element of surprise). Figuratively speaking, the position of the adversaries prior to engagement was reminiscent of two fencers, each of whom possessed identical weapons and knew that he would be attacked, but one of them nevertheless would fail to

parry an unexpected thrust. The one more skilled in tactics would be the victor.

While in one-on-one combat flying skill and gunnery training played the principal role in achieving success, in group combat it was skillful arrangement of the combat formation and change in formation from stage to stage. In the air fighting in Vietnam and in the Near East, with open initiation, the outcome would frequently be decided by the attack run by the attacking group, while conditions for gaining the element of surprise would be provided by a diversionary maneuver by the decoy group. In the war in Korea the enemy's combat formation would be split by a dagger-thrust pass by the lead group, while the attack group would attack the enemy aircraft, which were deprived of support.

There can be many variants of arrangement of forces and change in combat formation, and selection of the optimal variant is the first step taken by the executing individual who is modeling a group air engagement. The second step is distribution of missions among groups of differing designation and determination of the sequence of their engagement. Thus move-by-move progression began not at the moment the adversary was detected but long before that, when the logic of combat had already been determined by the executing individual. Appropriate here is comparison with a chess player who begins the game with a predetermined opening. I emphasize -- only an opening, that is, the initial stage of the contest. Nobody has yet succeeded in mentally playing through an entire game alone prior to its beginning. This must be clearly understood by the individual who is proceeding to model an air engagement if he lacks a two-cockpit semifull-scale simulation complex or is not counting on one decisive attack pass.

Also indicative, however, is another example. The grand master differs from the master, and particularly from the novice not only by a more highly developed and focused mental process but also by the ability to make the first 10 moves in any situation without thinking about it, but correctly. As experience indicates, the initiative is seized most frequently at this stage.

Modeling of aerial combat ends with decision-making (or approval by the commander of an optimal variant plan). Here one should bear in mind that there have been no identical engagements, but only similar ones. Therefore there can naturally be no identical plans. The plan adopted for execution is always calculated for a concrete situation. Therefore one can limit oneself to principles and stages, without citing a solution example. However, it is possible to shape the thrust of tactics for two aircraft with dissimilar performance characteristics.

Let the first be the aircraft with a better thrust-to-weight ratio and the second -- an aircraft with a lower wing loading (better maneuverability). Experience indicates that the pilot of the first aircraft sought to gain an

advantage by adhering to the following principles: element of surprise in the first pass; the endeavor to keep the adversary at a distance ensuring rapid closing; in the dynamics of combat -- a series of passes with separation from the adversary and preference to vertical maneuver; an intelligent expenditure of energy, which is easier to accumulate in a straight line. The pilot of the second aircraft observed the following principles to achieve success: the element of surprise in the initial pass; the endeavor to enter close combat; in the dynamics of combat -- a continuous turn toward the adversary, preference to horizontal steady-state maneuver (conservation of energy).

In general one can state that the first pilot concentrated on maintaining distance in the engagement, and therefore he could adhere to the tactics of "series of passes" (advantage at the first stage). The second pilot concentrated on maneuver after engagement in close combat (advantage at the second stage). In group combat and with an unequal correlation of forces, these principles were retained for the most part.

Thus modeling, which performs the role of binding element between theory and practice, constitutes one of the effective methods of investigation of air combat. The closest to actual combat is a physical model, experimentation in the air. But this is not always possible. Any other analog does not sufficiently fully reflect all properties of combat between aircraft in the air, and therefore the results of the investigation are considered approximate. At the same time the simplest game models, which have their place in practical flight operations, have some things in common with actual combat in principles of structure and functioning. This positive property of models is utilized for seeking optimal solutions in concrete situations.

Definition of Model

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 7, Jul 77 signed to press 31 May 77 pp 12-13

[Article by Lt Col A. Yena, Military Pilot 1st Class: "What Is a Model?"]

[Text] I read with interest the article entitled "From Copying to Originality" (AVIATSIYA I KOSMONAVTIKA, No 3, 1977). The authors raise the important question of innovative approach to preparing aircrews for missions on the basis of modeling methods.

The word "model" has firmly entered our lexicon, particularly in recent years. Experience shows that today it is impossible effectively to realize the combat capabilities contained in third-generation aircraft without thorough calculation of a mission and without a thorough analysis of its model.

When speaking of mission modeling, however, one should have a clearer concept of the meaning of the word "model." Let us turn to the S. I. Ozhegov Dictionary of the Russian Language. It states that a model "is a smaller (or full size) reproduction or scheme of anything. Ship model. Flying model of an airplane." And modeling is first and foremost the process of building a model, followed by examination of the model. Examination is an analysis of a flight mission model, as a result of which we select the optimal variant for the actual flight.

From this it becomes clear that in the process of constructing the model it is only partly studied. The full process of examination of the properties of an object on a model takes place after the model is completely constructed in any form. Everybody knows, for example, that before an airplane is built a model is constructed, either full-scale or scaled down. After the model has been built, one proceeds to study it, such as with wind tunnel testing. It can happen that modeling has occurred with partial examination (an aircraft model has been built), but a full study did not occur -- the aircraft became obsolete.

And now a few words about model examination proper. The authors of the article emphasize that on preparing to fly into the practice area the pilot had studied nothing, but copied a methods elaboration of a flight into the practice area, memorized this copy, and that was the extent of preparing for the mission, that is, no modeling occurred.

But in our daily lives, under actual conditions, things do not happen this way. A methods elaboration is a model of a flight, in this case into the practice area, carried out in the form of a diagram as a model. As a rule such a model indicates the sequence of performance of maneuvers and the principal flight parameters (speed, G-loads, banking, altitude).

And yet every pilot, preparing for a training mission to the practice area, does not simply copy a methods elaboration but prepares his own model, which will be supplemented by considerable information in comparison with the original model. First of all he will consider the weather on the day and even at the hour of the training mission, which cannot be taken into consideration in the original model diagram. Then he will analyze the air situation, which as a rule very strongly influences maintaining altitude and position in the practice area. He will direct attention to the time of day and season, that is, how these elements will affect visibility of ground reference points and orientation as a whole. Many pilots know, for example, that it is considerably easier to fly in the practice area at midday than just before sundown.

Thus the process of supplementing the flight assignment with new elements and analysis of the influence of these elements on its performance constitutes constructing a new flight model and its examination. Having thoroughly analyzed the new model, the pilot concludes on how he can best perform the mission.

There is no doubt that models of different flight assignments require a different volume of investigation. But to one degree or another the element of investigation is characteristic of preparing for any flight.

Further on in the article it is stated that the most graphic example of a symbol model is the scheduled flight operations table. I cannot understand why the authors needed to "make a science" out of an ordinary schedule. Following their logic, everything can be made into a model, and yet the Dictionary of the Russian Language and the Great Soviet Encyclopedia rigorously define what a model is and what modeling is.

It is emphasized at the end of the article that "there exists a certain caution in regard to modeling. The most typical question is the following: can't it be done more simply?" I see nothing reprehensible in this question. Every pilot is a great practical expert. In any theoretical question he perceives first and foremost a practical aspect, that is, how effective the modeling method is in preparing for missions. To demonstrate the effect of modeling and its significance, and in understandable form, is the task of higher educational institutions and scientific research institutes. Pilots should be given methods of studying models which would render substantial assistance in preparing for missions or to a commander in making flight decisions.

Computers and Control

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 7, Jul 77 signed to press 31 May 77 pp 36-37

[Article by Academician V. Glushkov, Director of the Order of Lenin Ukrainian SSR Academy of Sciences Institute of Cybernetics: "Computer Advances"]

[Text] Computers play an enormous role in a number of branches of science and sectors of the economy. They also occupy a prominent place in the development of aviation and space exploration, particularly in the performance of complex engineering computations in designing modern aircraft, spacecraft, rockets, in automating testing of finished equipment and flight operations control activities.

Today electronic computers serve as a foundation in building air traffic control systems around domestic large airports and even on an international scale. High-intensity traffic and efficient utilization of aircraft becomes practically impossible without computers. Space exploration is inconceivable without computers. With the aid of these machines experts calculate spacecraft trajectories, that is, perform ballistic trajectory computations. Computers help process information received from spacecraft and satellites.

For manned space missions, computers are employed to simulate on the ground both a spacecraft flight and the operation of all its systems. This is essential for swift decision-making in a complex situation, such as when a

system goes beyond the limits of a precisely-specified mission program due to various equipment malfunctions and other unexpected events which can occur as a consequence of any external factors.

In a number of the above-enumerated areas, particularly in the area of automation of complex computations connected with design activities, processing of an enormous mass of information coming in from space, weather forecasting data, for example, computers of ever-increasing capacity are required. It is necessary to expand such computer parameters as speed and increase in the capacity of internal and external memory. The state of and process of development of large computers for these purposes is defined in this country primarily by the uniform series of computers of the nations of the socialist camp (YeS EVM).

This series covers a broad range of computer operating speeds, from tens of thousands to several million arithmetic operations per second. External storage capacity is also rather large. For example, at least 1 million bytes of main memory are offered in the top-of-the-line models of this series, while in principle the figure could be boosted to 16 million bytes (byte -- a symbol which includes two digits or one letter). This is the main memory capacity. External storage volume is also determined chiefly by magnetic disks. Small-capacity (7.25 million bytes) magnetic disks are now being replaced by disks with 29.5, 100, and in the near future 200 million bytes per unit. And quite a few such devices can be connected to a computer.

With the adoption of new systems, the approach to programming is also changing. In the past separate, as a rule not too long programs would be run on the majority of computers, while today there is a capability to run more complex and longer programs. Means of automating programming and program editing are extensively employed for this purpose, making it possible efficiently to run much larger programs. However, in the near future, when incomparably greater speed will be required, such speeds and computation capacities will be inadequate.

Fourth-generation computers will employ large integrated circuits, containing on a single silicon crystal thousands of elementary logic elements with corresponding semiconductor high-speed memory. These computers will come on-line in the current five-year plan, while subsequently they will become the foundation for further growth and development of high-capacity Soviet computer hardware, linking together not one but dozens of such elementary processors. Thanks to this it will be possible to increase summary computer speed from one to three million operations per second (typical of the current period of development of computer hardware), let us say, to 100 million and more, that is, it will be increased by almost 100-fold.

All this is of fundamental significance for increasing accuracy and speeding up calculations and processing of enormous quantities of various data.

It is understandable that weather information utilized for daily forecasts requires very rapid machine processing. An increase in speed of calculation plays an enormous role here. It will become possible to obtain fairly accurate global weather forecasts, initially short-range, and subsequently longer-range. This also applies to the investigation of geologic structure, vegetation cover, as well as many other features of the earth in studying it from aircraft and space vehicles.

The linking together of large computers concentrated at electronic data processing (EDP) centers into large multiple-computer systems is today acquiring great importance. Such systems are being established even with computers which already contain a large number of processors. These complexes in turn are interlinked by means of communications channels and computer systems and are sited at various locations. The result is computer networks which in the final analysis will include all the computer capabilities of a country or group of countries on an international scale. Establishment of such networks is also important for the further development of aviation and space exploration.

During missions in space, for example, information collection points are situated throughout the USSR. If a spacecraft goes out of line-of-sight radio contact with any specific locality, communications with it are not interrupted, and information comes in continuously. Information transmission to a single point for processing is frequently inexpedient. This is why it is essential to have local EDP centers. But then locally processed data will not produce an overall picture of the flight.

In order to obtain a complete picture of a spacecraft mission and on the state of its crew, EDP centers engaged in processing information must constantly exchange data with one another. Consequently an entire network of computers is required.

Similar tasks arise in the case of air traffic control over a large territory. EDP centers concentrated around major airports or at radio navigation beacon sites receive information on air traffic, including monitoring information from air surveillance radars, perform aircraft identification, determine their speed, altitude, etc. When all EDP centers are exchanging information, the entire system as a whole will recreate not simply a mosaic made up of individual little pictures but will present a genuinely objective picture of air traffic within the airspace of a single country or a group of countries. Only with such a system is it possible efficiently to control air traffic and intelligently to utilize alternate airfields. This will increase both the speed and regularity of air traffic, will make flying safer and reduce operating costs.

Such computer systems are also needed for conducting tests, such as for automating wind tunnel tests and experiments involving gas dynamics, scaled-down and full-scale models, and for testing aircraft engines. Computer systems are also essential for total automation of designing complex items, for it is well known that large groups of specialists from different organizations, which are frequently at a considerable distance from one another,

participate in design projects on modern aircraft and spacecraft. Therefore effective work on designing such complex systems is possible only if there is a continuous exchange of information between computers.

And now about the future. It is believed that the fourth-generation computer will be followed by even faster computers designed on the basis of new physical principles. They will extensively employ optoelectronics, holography, and low-temperature technology. They will open up fundamentally new possibilities of increasing the speed of computer elements. There are also ideas on organizing components and separate elements into a system of computers, development of so-called recursive computers. There are also other trends in computer development, making it possible to run computers in parallel, thus obtaining maximum operating speed.

As regards special-application computers, including computers carried on board spacecraft, satellites and aircraft, as well as some auxiliary computers employed for automating testing and simulators, the primary problems (particularly applying to on-board computers) are size, weight and reliability.

With the development of large integrated circuits (LIC), the degree of integration of individual logic elements has reached such a level that a single crystal of silicon measuring a fraction of a square centimeter can in actual fact represent, if not an entire computer, at least individual computer units, accommodation of which in the past required entire equipment cabinets. For example, today a central processor, that is, a computer arithmetic unit and control unit, can be contained on a single chip.

A fairly large volume of high-speed main memory can be provided with two, three, or four LICs. By adding a few more LICs, one can obtain channel equipment which will control communications with input/output devices or with external storage units. As a result of the employment of LICs, the size, weight and power requirements (which is extremely important for on-board equipment) are sharply reduced. In addition, utilization of various devices involving not only simple double and triple equipment redundancy but also the employment of new structural principles increases computer reliability. These include utilization of a special coding system and error-correcting codes within the computer. And not only during transfer of information from one unit to another, as is done today, but directly in the information processing circuits, during performance of arithmetic operations.

Such error-correcting codes make it possible automatically to correct one or even several errors occurring randomly in the process of operation, and thus ensure very high computer reliability, so high that one can replace with a single computer numerous local control systems typical of aircraft of the end of the 1960's and beginning of the 1970's. In the past such systems (autopilots), responsible for an aircraft's movement along specified trajectory, direction and altitude, required special analog equipment, while today these processes can be controlled by an on-board computer.

The role of on-board computers on spacecraft is also becoming greatly enhanced today. They can assume an increasingly large number of diversified functions, with a simultaneous improvement in reliability. Here there arise questions connected with the design of viable systems in which overall output will diminish when certain units fail but the principal task will still be performed. This is extremely important particularly for deep-space exploration. The principle utilized in controlling a lunar rover, where a human operator is on the earth and controls the movement of the vehicle, is inacceptable due to the considerable signal transmission delay. This delay can amount to several hours even within the confines of the solar system.

Therefore it is essential thoroughly to study the possibilities of increasing the capacity of the computers which will be carried on board a spacecraft to Mars, a satellite of Jupiter or other planets in the solar system. Such research is also necessary for building versatile robots which are able to orient themselves independently, to make decisions in unexpected situations and to carry out purposeful behavior. Of course for this it is necessary to solve problems not only involving control of the behavior of the robot proper, but also acquisition of information from the environment for elaboration of purposeful behavior. Thus the robot should have eyes (including a range finder), organs of hearing and touch, and should also be capable of precisely transmitting appropriate information to the central processing unit. Here on the one hand it is necessary to reduce the size and cost of the computer proper, reduce power requirements and weight to a minimum, to increase reliability to a maximum, while on the other hand it is necessary to achieve extremely high operating speed.

The convergence of these two trends in the development of large and small control computers will become possible when large computers will offer even better performance, performing tens and hundreds of billions of operations per second. Then we shall evidently begin developing small control computers as well, which will be equal in computation capacity to today's large computers, or even superior to them. Herein lies the dialectics of development, for in the past we considered minicomputers to mean tens of thousands of operations per second, while today mini- and microcomputers can perform millions of operations per second.

Thus electronic computer hardware comprises one of the most rapidly-developing branches of modern industry. And it is difficult to predict what level of development will be achieved by electronic computers beyond the 20th century, for example. It is obvious that they will be considerably more potent, and it will become much easier for man to work with them.

The line of development of computers connected with an increase in the intellect of computers is important not only for aviation and astronautics but also for the entire national economy as a whole. We are dealing with a transition from simple machine structures to brain-like structures, reminiscent of the structure of the human central nervous system and superior to it in speed of operation and computation capabilities.

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FOLLOW-UP REPORTS ON PREVIOUSLY REPORTED DEFICIENCIES

Military Construction Sites

Moscow KRASNAYA ZVEZDA in Russian 2 Jul 77 p 2

[Text] "The Fetters of Deception"--That was the title of the correspondence of Lt Col-Engr L. Kulikov published on 25 May of this year. In it were criticized a number of supervisors of military construction sites and of barrack service organs who had allowed distortions in bookkeeping statistics upon putting living quarters into use.

As the first deputy chief of construction and billeting of the USSR Ministry of Defense, Gen Lt-Engr N. Shestopalov, informed the publisher, the criticism was admitted to be justified. The correspondence was discussed at a conference of the leadership of the construction administration and its subordinate organizations.

The supervisor of the construction organization, Col-Engr I. Parkhonyuk was reprimanded by order of the USSR deputy minister of defense for construction and billeting for deficiencies allowed in the work, absence of effective control over the quality of construction, and untimeliness in turning over living quarters for occupation. The chief engineer of that collective, Lt Col-Engr S. Starovoytov, and also the chief of the UNR [Work Supervision Section], Col-Engr. M. Pitkin were given severe reprimands. The political department of the party commission imposed party punishment on Col-Engr M. Pitkin--a severe reprimand with annotation on his registration card. Other responsible persons were also punished.

In accordance with the instructions of the USSR deputy minister of defense for construction and billeting, a number of measures are being prepared which are aimed at raising the personal responsibility of construction supervisors for timely turnover of construction projects for use and for high quality construction.

Repairing Heating Systems

Moscow KRASNAYA ZVEZDA in Russian 3 Jul 77 p 2

[Text] "In The Very Same Place..." - That was the title of the correspondence of A. Tertychny published in the paper on 12 May. In it were criticized deficiencies in heating of living quarters under the jurisdiction of one of the quartering units of the Kiev Military District.

As the supervisor of the district quartering directorate, Col-Engr D. Khmura, informed the publishers, the facts stated in the correspondence were confirmed. Necessary measures were taken to eliminate the deficiencies. The district quartering directorate took under its control the accomplishment of work on repairing the heating system. Four houses occupied basically by persons who had lost their connection with the army were transferred to the jurisdiction of the local soviets. The supervisor of the quartering unit, Lt Col-Engr V. Gorbunov was severely reprimanded for negligence in considering the complaints and statements of the residents.

Railroad Transport

Moscow KRASNAYA ZVEZDA in Russian 3 Jul 77 p 2

[Text] "Who Will Eliminate the Cement 'Bottlenecks'?"--That was the title of the correspondence published in the paper on 28 April. In it deficiencies in the use of railroad transport by a number of military construction organizations and construction industry enterprises of the USSR Ministry of Defense were criticized.

As Gen-Lt-Engr A. Karaoglanov and Gen Maj-Engr Ya. Troyan informed the publisher, the facts set forth in the newspaper article were confirmed. The correspondence was attentively studied and discussed by the command of construction organizations and enterprises. For poor control of the unloading of railroad cars, lieutenant colonels A. Sukhinin and A. Avdeyev were reprimanded and engineer colonels V. Kostrikin, V. Dukhin and M. Chernom received admonitions.

To prevent excessive stoppages of railroad cars being unloaded, measures have been taken for more rhythmic shipping of cement by supplying enterprises, mechanization of loading and unloading work, raising the capacity of warehouses and obtaining timely information on arriving cargoes.

Food Services

Moscow KRASNAYA ZVEZDA in Russian 13 Jul 77 p 2

[Text] "Indifference"--Under this title on 2 June was published the letter of Warrant Officer [praporshchik] D. Gazizov which was commented on by KRASNAYA ZVEZDA correspondent Lt Cmdr A. Zlydnev. The discussion concerned the reasons which led to the destruction of the kitchen greenhouse of "N" unit.

The deputy chief of the political department informed the publisher that the newspaper article was discussed in the political department and also at a meeting of the command element of the unit. Measures were taken to improve the troops' living conditions and to expand the food service. The greenhouse being created in place of the one that was destroyed must be prepared by 30 July. Control has been established over the progress of the work.

Military Justice Training

Moscow KRASNAYA ZVEZDA in Russian 17 Jul 77 p 2

[Text] "In Moving From the Judicial"--Under this heading was published on 21 May of this year an article by Lt Col of Military Justice I. Vashkevich. It discussed in particular some deficiencies in the practice of military justice training in "N" unit. The acting chief of the political department, Maj Plichko informed the publisher that the article has been studied at meetings of officers, warrant officers and party and Komsomol activists. The critical remarks expressed in it were admitted to be correct. A plan to eliminate the mentioned deficiencies has been put together by the political department.

In the subunits, evening meetings were conducted on the theme of "Strict and Precise Execution of Soviet Laws - The Duty and Obligation of Each Serviceman." A topic evening on "Drunkenness - The Road to Crime" is being prepared.

Servicemen's in-town leaves are now implemented in a strict conformity to regulation. The role and responsibility of company and platoon commanders in maintaining internal order in the subunits in accordance with regulations have been heightened. A discussion has been conducted with the chief of military vehicle inspection for the garrison on the need for strict observance of legality.

The command element, political department and party and Komsomol organizations are paying great attention in their practical work to fostering in personnel responsibility for fulfilling Soviet laws, the military oath and military regulations.

9069
CSO: 1801

COMPLAINTS FROM READERS

Veteran Complains About Unceremonious Separation

Moscow KRASNAYA ZVEZDA in Russian 15 Jul 77 p 2

[Letter from Reserve Lt Col of Technical Services A. Sizyakov with editorial comment: "The Postman Delivered the Awards"]

[Text] I gave more than 26 years to service in the army. I fulfilled my military duty honorably. My award in connection with transfer to the reserves of the medal "Veteran of the USSR Armed Forces" and certificate bears witness to this.

But as strange as it may appear, namely upon receipt of these awards, I felt insulted. You see, I received them...by mail. Moreover, the comrades of the headquarters of rear services of the Far East Military District were apparently in such a hurry to finish up with the "formalities" that they did not even complete the certificate for the medal. Let the awardee himself, they figured, write in his name on the document and put the seal in the right place.

I am sure that such regard for veterans brings nothing but harm to the education of officer cadres.

From the Editor--This letter was already prepared for the press when an explanation arrived from the rear services headquarters of the Far East Military District: The lack of tact with regard to Comrade Sizyakov was displayed only because in the past he had been commander of the unit. So he was sent the packet, the contents of which he was to present to himself...

Discrepancies in Naval School Noted

Moscow KRASNAYA ZVEZDA in Russian 15 Jul 77 p 2

[Letter from Petty Officer 2d Class V. Zagarovskiy: "Detrimental to Training"]

[Text] Dear Editor! I was prompted to write in the hope that my letter may prove useful in the matter of improving the training process in our subunit.

My duty is that of a shift instructor. For several years our shift has retained an excellent rating, but that is not what I wish to discuss.

Almost every morning concurrent with the review for classes there begins a "review for work" which is not provided for in any regulations. I do not have in mind morning exercises. A certain number of hours is devoted to them from the training program. But the sailor-students from my shift, and not only from mine, very often are made to take part in general garrison work related, for example, to improving the facilities of the city. The permissible norm for breaks from the training program is thus exceeded by two or three times. You glance at the class and it is one-third empty. And you know, we are preparing specialists for the ships, and they then stand watch in the oceans on operating machinery.

Of course, by intensive additional efforts of the officer-teachers and instructors, the gaps in the knowledge of the young sailors are gradually eliminated, but really, is this a rational way out of the situation?

The fact that there are not enough textbooks is also disturbing; for example textbooks for bilge mechanics. It is true that the detachment command element is doing everything possible to get out of this situation, and is duplicating summaries on the printer. But wouldn't it be simpler to republish a reference text so necessary to the navy?

9069
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MARSHAL MOSKALENKO RECALLS RED ARMY'S ROOTS, LAUDS PARTY ROLE

Moscow SOVETSKAYA ROSSIYA in Russian 18 Sep 77 p 2 LD

[Article by Marshal of the Soviet Union K. Mosalenko, USSR deputy defense minister: "The Army of the Working People"]

[Text] From the earliest days the defense of the socialist fatherland was a most important task and practical concern of the young republic. In its first state enactment the Soviet Government proclaimed peace as the basis of its foreign policy. But the young republic's peace initiative was met with hostility from international reaction. Armed intervention, combining with counterrevolution within the country, demanded quick and decisive organization of the state's defense. At the beginning of 1918 the Soviet of People's Commissars was already, at V. I. Lenin's suggestion, adopting decrees on the organization of the workers' and peasants' Red Army and the Red Navy, and in July of that year the 5th All-Russian Congress of Soviets consolidated the change from the voluntary principle in the formation of Red Army units to universal obligation to do military service. The whole of subsequent history has confirmed the timeliness and necessity of these acts; Lenin's ideas on the defense of the socialist fatherland serve even now as a true compass in determining ways of strengthening the country's defense and military building.

Having given 57 years of my life to military service, I have been not only a witness to but also a participant in the creation of the new type of army. Before my eyes it has traveled the long path from the first Red Army regiments to the mighty armed forces, covered with combat glory, which are the reliable guardians of our people's peaceful labor. In conditions of famine, economic devastation, sabotage and counterrevolutionary revolts the party was able to raise and inspire the working people to fight the enemy. Revolutionary soldiers, sailors, workers and peasants fighting in the ranks of the Red Army showed infinite devotion to the young Soviet republic and mass heroism; they knew that they were fighting for something close to them, something of their own.

After ending the Civil War and rebuffing the foreign aggressors, our people, under the leadership of the party, began to build socialism and to implement broad reforms in all spheres of life. But while carrying out gigantic work on the formation and development of the national economy and the raising of the people's culture and education, the party never for a moment relaxed its vigilance and constantly gave attention to the strengthening of the defense capability of our motherland and to military building.

The treacherous attack by fascist Germany made us take up arms again. Our people accomplished a great feat in that most terrible of wars. The Soviet Union's victory over fascist Germany and its allies showed that there is no force in the world which can smash socialism or bring to their knees a people true to the ideas of communism and rallied around the Leninist party.

In battles with the fascist hordes the high courage of the Soviet Army and the leadership talent of its outstanding military commanders were displayed, and the greatness of spirit of the Soviet soldier was revealed to the full. Not only was he able to uphold the freedom and independence of his socialist motherland, but also he made a decisive contribution to the salvation of European and world civilization from the Fascist barbarians.

Those difficult years are receding farther and farther into the past. Lasting peace is the main condition for the realization of the impressive plans by which our country now lives.

We know that the party and the Soviet state are actively and persistently struggling for the preservation of peace, for the curtailment of the arms race and for disarmament. This has made it possible recently to achieve considerable results in the development and deepening of the policy of relaxation of tension. At the same time it cannot be forgotten that there are forces in the world which are trying to hinder this progress in every way. Aggressive imperialist forces are whipping up the arms race, above all for nuclear weapons, and are creating a new threat to the peace and the peoples' security. Under these conditions the Central Committee of our party and the government are doing everything to insure that the defense capability of the Soviet state and the might of its armed forces are always up to the mark. Questions of military building are constantly at the center of attention of the CPSU Central Committee Politburo and of Marshal of the Soviet Union Leonid Ilich Brezhnev, general secretary of the Central Committee, chairman of the USSR Supreme Soviet Presidium and chairman of the State Defense Committee, in person.

The basis of our military doctrine and of all military building was and remains the unity of a peaceful foreign policy with the readiness to give a real rebuff to any aggressor. The strengthening of the USSR's defense capability answers not only the interests of our state and the other socialist countries. Objectively it also serves the cause of insuring world peace and the peoples' security.

Recent successes in science and technology and the increased economic potential of the country have made it possible to equip the army and navy with the most excellent weapons and combat equipment for various purposes. The combat potential of all branches of the armed forces has grown, and the basis of their military power consists of the strategic missile troops, the nuclear submarine fleet and missile-carrying aircraft. The pride of the Soviet Armed Forces are the commanders, political officers and engineering and technical cadres, the soldiers, sailors, sergeants and chief petty officers--worthy successors to the tradition of the soldiers of the Revolution.

Given birth by Great October, tempered in the battles of the Civil War, covered in everlasting glory in the battles of the Great Patriotic War, our valiant armed forces stand vigilantly on guard over the creative labor of the Soviet people, on guard over peace throughout the world.

CSO: 1801

MARSHAL OGARKOV ON HISTORY, ROLE OF USSR ARMED FORCES

Moscow KRASNAYA ZVEZDA in Russian 27 Oct 77 p 2 LD

[Article by Marshal of the Soviet Union N. Ogarkov, chief of the USSR Armed Forces General Staff and USSR first deputy defense minister: "The Defense of the Socialist Fatherland is a Matter for All the People"]

[Text] Our motherland is greeting(s) its 60-year jubilee on the very frontlines of social progress. The eve of this remarkable festival has been marked by an event of worldwide historic significance--the adoption of the New USSR Constitution, which, as Comrade L. I. Brezhnev stressed in his report at the Extraordinary Seventh Session of the USSR Supreme Soviet, is "the concentrated result of the whole 60-year development of the Soviet state."

By directing the energy of millions toward the solution of the tasks of building a new society, and by struggling consistently and firmly to insure peaceful conditions for this building, the Communist Party throughout the difficult but glorious path traversed by the land of the soviets has shown and continues to show tireless concern for the country's security and defense capability. The New USSR Constitution proclaims that the defense of the socialist fatherland is among the most important functions of the state and is a matter for all the peoples.

I.

The question of the proletariat's armed defense of its socialist gains occupies one of the most important places in Marxist-Leninist teaching about the revolutionary transformation of society. In a number of their works, K. Marx and F. Engels noted that to bring about a victorious revolution, to strengthen the proletariat's power and to build socialism, the proletariat must have its own military organization. Developing these ideas, V. I. Lenin created, on the basis of an analysis of the monopoly stage of developed capitalism, an integral and well-composed doctrine about the defense of the socialist fatherland. He comprehensively substantiated the objective need for such defense and pointed out the

specific ways, forms and methods of strengthening the defense capability of the worker-peasant state and of creating and improving its military organization.

Lenin's teaching about the defense of the socialist fatherland and the principles of the military organization of the socialist state which he devised lie at the basis of the party's policy in the sphere of strengthening our country's defense capability, military building and the leadership of the armed forces. V. I. Lenin's ideas have received further creative development in the decisions of CPSU congresses and CPSU Central Committee plenums, in the party's program and in other party documents.

The provisions of Chapter 5 of the New USSR Constitution are wholly imbued with these ideas. Defining the defense of the socialist fatherland as the most important function of the state and as a matter for all the people, it proclaims: The USSR Armed Forces have been created and universal compulsory military service has been established for the purpose of defending the socialist gains and the peaceful labor of the Soviet people and the sovereignty and territorial integrity of the state. The duty of the USSR Armed Forces to the people is to reliably defend the socialist fatherland and to be in a state of constant combat readiness which insures the immediate rebuffing of any aggressor.

In terms of their class nature and political purpose, the USSR Armed Forces differ fundamentally from all the types of armed forces that have preceded them, representing a military organization of a new, socialist type. The creation of this organization, which was carried out for the first time ever by the Communist Party under the leadership of V. I. Lenin, was an act of historic significance and was a specific expression of one of the general law-governed patterns of the epoch opened up by the Great October Revolution.

V. I. Lenin and the Communist Party solved the task of creating the armed forces of the socialist state in organic unity with the general tasks of party and state building and of building socialism. "The building of our army," V. I. Lenin observed, "could lead to successful results solely because it was created in the spirit of general Soviet building..." ("Complete Collected Works, Vol 40, pp 76, 77).

Purely military measures were carried out by the party in conjunction with economic, political and social measures which insured, under the very difficult conditions of the Civil War and foreign military intervention, the young Red Army's successful fulfillment of its tasks of defending the socialist fatherland. Linked with the people by unbreakable bonds and possessing a high level of political awareness and iron military discipline, it displayed to the world unprecedented examples of stanchness, courage and mass heroism.

In the period of transition from capitalism to socialism the party, conforming to the program tasks of building a new society, consistently pursued a peace-loving foreign policy course. At the same time it realistically took account of the invariable, reactionary essence of imperialism and of its preparations for a new aggressive war against our country, and it adhered firmly to Lenin's instruction that "we must accompany our steps toward peace with the intensification of our entire military readiness..." (Vol 40, p 248).

The implementation of the fundamental directives drawn up by the party in the sphere of military building was insured by the very profound socio-economic transformations in the country and by the Soviet people's selfless labor and inexhaustible creative activity. This made it possible in the shortest possible historical period to cardinally resolve the problems of raising the state's military-economic potential and to create the necessary conditions for the steady strengthening of its defense capability, for the full technical reequipping of the armed forces and for the moral-political tempering of the personnel.

The strength of our socialist state and the reliability of its defense were subjected to the severest testing in the years of the Great Patriotic War. Only a free, stanch and courageous Soviet People, closely rallied around their tested combat vanguard--Lenin's party--could endure the infinite burden of sacrifices and privations which lay at that time upon its herculean shoulders. Only our socialist armed forces proved capable of holding out in the savage fight against the gigantic war machine of German fascism, which had been mobilized and deployed in advance and which treacherously attacked our country. They managed to turn this machine back and to utterly rout the aggressor. In accomplishing this unprecedented feat, the Soviet people and Soviet servicemen honorably fulfilled their patriotic and internationalist duty. They defended the freedom and independence of their own motherland and made a decisive contribution to the cause of saving European and world civilization from destruction at the hands of the fascist barbarians.

The victory of the Soviet people and their armed forces in the Great Patriotic War was historically natural. It convincingly demonstrated the total superiority of the state and social system engendered by the October Revolution and of its economy over capitalism and once again showed graphically the vivifying strength of Marxist-Leninist ideology and the might and invincibility of the socialist state's military organization. It confirmed the correctness of Lenin's words to the effect that people who are defending their own rule, their own just cause and their own radiant future can never be beaten.

The effective realization of economic, moral-political, scientific, technical and strictly military potentials in the difficult war years was guaranteed, thanks to the CPSU's leadership.

II.

The leadership of the Communist Party was, and still remains, a decisive source of the might and invincibility of the Soviet Armed Forces, the unshakable foundation and the supreme principle of state and military building.

The contemporary period--the period of mature, developed socialism--is characterized by the continuing enhancement of the party's leadership role in society and the intensification of its theoretical, political and organizing activity. "As the Soviet people solve increasingly complex and crucial tasks in building socialism," Comrade L. I. Brezhnev, general secretary of the CPSU Central Committee and chairman of the USSR Supreme Soviet Presidium, said in his report at the Extraordinary Seventh Session of the USSR Supreme Soviet, "the role of the Communist Party will increase more and more."

Armed with Marxist-Leninist teaching, the Communist Party, as the USSR Constitution states, determines the general perspective of society's development and the USSR's domestic and foreign policy line. In full accordance with this, on the basis of a profound Marxist-Leninist analysis of the international situation and of the arrangement of military-political forces in the contemporary world, and taking into account the laws of social development, the achievements of science and technology, and the political, economic, spiritual and military resources of the Soviet state, the party solves the tasks of the development of the military sphere, the strengthening of the country's defense might, the enhancement of the armed forces' combat readiness, and their development and improvement.

The steps being taken in this direction are forced upon us. While struggling consistently for the further deepening of positive processes in international life, for justice, stable peace and cooperation among states with different social systems, the CPSU at the same time takes into account that, although the possibilities of aggressive action by imperialism have now been considerably reduced, its reactionary class essence remains the same as ever. The imperialist reaction is attempting to retard the positive processes in relations among states of various social systems and to return mankind to the times of the Cold War. Not disdaining direct deception of its own peoples, it is seeking to whip up the arms race by seeking ever higher appropriations for new lethal and inhuman weapons systems. In fiscal 1977 U.S. military spending, for example, amounted to $113 billion. In 1978 it will rise to $118 billion. The proposed military budget for 1980 will amount to $150 billion and that for 1985 will be $200 billion. The military budgets of the FRG, Britain and other countries of the aggressive imperialist NATO bloc are constantly increasing. The lion's share of this money is being channeled into the development of new types of arms--cruise missiles, submarines of the Trident system, MX ICBM's, laser and radiological weapons, and the neutron bomb.

Whipping up anticommunist, anti-Soviet hysteria, influential circles of the Western powers are continuing to interfere impudently in the internal affairs of many countries of the world, are intensifying terrorism against democratic and progressive forces in their own states and in foreign states, and are in every way maintaining and whipping up an explosive situation in a number of regions of the world. The present Chinese leadership is operating jointly with the most reactionary and aggressive circles of the West. Despite the interests of its own people it is feverishly carrying out the militarization of the country and is stubbornly adhering to an overtly anti-Soviet line in its policy.

It is perfectly understandable that under such conditions the Communist Party and Soviet Government have been forced to implement the necessary measures to maintain at the necessary level the defense potential of our state and the combat might of the USSR Armed Forces. Our country's spending on defense, L. I. Brezhnev observed, amounts to "exactly as much as is necessary for the reliable defense of the Soviet Union, for the defense of the gains of socialism together with the fraternal countries, and to insure that potential aggressors are not tempted to try to decide in their own favor, by force, the historical dispute between the two opposed social systems."

The strengthening of the country's defense capability is possible only on the basis of a highly developed economy, and above all, industry, which is capable of producing in the necessary quantities the complex and multiform military equipment, weapons, materials and personal equipment. Thanks to the Soviet people's selfless labor, our country's industrial might has achieved its highest ever level. Suffice it to say that our country's industrial might is now 18 times greater than it was when it served for us the foundation for achieving victory in the Great Patriotic War. Today the working people of our country turn out in less than a month a social product equal in volume to the social product of the entire year of 1936. Jointly with our motherland the fraternal socialist countries are achieving great economic successes, thus making a worthy contribution to the cause of strengthening the security of the countries of the socialist community. Whereas socialism's share in world industrial output in 1917 amounted to less than 3 percent and in 1937 to less than 10 percent, the figure is now more than 40 percent. The successful practical implementation of the 10th Five-Year Plan and of the historic decisions of the 25th CPSU Congress will certainly insure the further dynamic growth of the USSR's economy and will serve as a weighty contribution to the strengthening of the might of the entire socialist community.

The steadily growing potential of the socialist economy and the outstanding achievements of Soviet science and technology have made it possible to equip the Soviet Armed Forces with everything necessary for the reliable defense of the socialist gains. Our army and navy now have the most up-to-date weapons and combat equipment which make it possible to give any aggressor an immediate rebuff.

But the defense might of the socialist fatherland is not determined solely by the country's developed economy and by the armed forces being furnished with all types of first-class military equipment and weapons. One of the decisive factors of this might is the inexhaustible moral strength of our people and their army and their boundless devotion to the motherland and to the party's cause.

The spiritual wealth of the developed socialist society, the indestructible ideological unity of all classes and social groups and of all the national and nationalities of the country, the monolithic cohesion of the historically new social and internationalist community of people--the Soviet people, who are vitally interested in insuring the reliable defense of the socialist fatherland--all this embodies the vivifying sources of the high moral-political and combat qualities of the armed forces' personnel and of their readiness to carry out heroic feats for the sake of the motherland. A serviceman of the land of the soviets is a full and equal citizen of the great socialist power who possesses in full measure all the remarkable qualities of the Soviet man.

Educated by the party in the spirit of boundless devotion to the motherland and to the cause of communism and as ardent patriots and internationalists, Soviet servicemen are reverently loyal to their duty to the people, which is enshrined in the USSR Constitution--to reliably defend the socialist fatherland and to be in a state of constant combat readiness which insures the immediate rebuffing of any aggressor.

III.

The maintenance of the USSR Armed Forces' combat readiness at a level that conforms with modern requirements accords with the fundamental interests of the Soviet people and of the peoples of the fraternal socialist countries, because it is the most important factor in insuring peaceful conditions for the building of a new society and for the defense of the working people's revolutionary gains. This also accords with the vital interests of all progressive mankind, since it objectively serves the cause of strengthening peace on earth and the security of the peoples.

The armed forces' readiness is that condition which they can assume whereby the army and navy are capable of repulsing and frustrating aggression at any moment, under any conditions, no matter from what quarter this aggression may originate. "Combat readiness," Marshal of the Soviet Union D. F. Ustinov, member of the CPSU Central Committee Politburo and USSR defense minister, has stressed, "is an amalgam of the technical equipment of the troops, their military skill, moral-political, psychological and physical tempering, their organization and the readiness of each Soviet serviceman to execute heroic feats for the sake of fulfilling his military duty to the motherland.

Under present-day conditions in the age of nuclear missile weapons and other powerful means of armed struggle, the demands on combat readiness have grown immeasurably. Combat readiness covers all aspects of the multi-faceted activity of the armed forces and is attained by obstinate, persistent daily work, strenuous training, the constant improvement of the training of the command cadres and staffs and political organs and party organizations of the army and navy, the improvement of the style of their activity, and all-embracing party-political work.

A decisive role in raising combat readiness is played by the command, political, and engineering and technical personnel of the armed forces. The system of training military cadres is steadily developing and improving, and their ideological-political standard, education and culture and vocational skill are growing. Over 90 percent of army and navy officers are now communists or Komsomol members, and over half of them have higher military or specialized military education.

The improvement of the qualitative state of the officer corps and the raising of its qualifications help to increase the efficiency of the entire training and educational process, the rallying of the military collectives and the successful fulfillment of training programs and plans and tasks of operational, combat and political training. The maintenance of combat readiness at the necessary level depends above all precisely on this--on the steady improvement of methods of training and educating the personnel, on the insuring of a precise and stepped-up rhythm of work at exercises and firing practice, missile launches and the driving of combat vehicles, in flights and sea voyages and in tours of combat duty.

The improvement of the quality of combat training is a task of state importance. It is no accident that the CPSU Central Committee report to the 25th party congress spoke of how this task is being resolved.

The Soviet state, as the Constitution proclaims, insures the country's security and defense capability and provides the USSR Armed Forces with everything they need. Thanks to the tireless concern of the party and all Soviet people, our army and navy keep abreast of present-day scientific and technical progress.

The provision of the troops and naval forces with the latest equipment and weapons invariably entails changes in military art--in strategy, operational skill and tactics and the forms and methods of combat operations. In this connection the growing role and significance of Soviet military science, which is becoming an increasingly active motivating force and one of the effective means of improving combat and operational training and the system of the troops' training and education and of raising their combat capability and combat readiness, are obvious.

An important contribution to the raising of the country's defense capability and the combat readiness of the Soviet Armed Forces is made by the Komsomol, DOSAAF organizations and collectives of training establishments, enterprises and institutions and collectives of training establishments, enterprises and institutions in which young men prepare to fulfill their honorable duty--service in the army and navy. Thanks to their active, purposeful work, young people with good general educational training and possessing a particular speciality necessary for military service are now coming into the Soviet Armed Forces.

The present stage of development of our armed forces is characterized by the further consolidation of their unity with the people. Under the conditions of developed socialism the servicemen's ties with the urban and rural workers are becoming increasingly rich and varied. Army and navy personnel are taking an active part in the country's sociopolitical and economic life. The voice of the servicemen was heard at full strength in the period of nationwide discussion of the draft fundamental law of our motherland. Together with all the people they are working the pre-October jubilee shift in a fitting manner. The patriotic Naro-Fominsk initiative has been widely and actively supported in all military units and on the ships. A movement has been launched in the army and navy under the slogan "A shock finish for the jubilee training year!"

Soviet servicemen are welcoming the glorious 60th anniversary of October with successful fulfillment of pledges in socialist competition, with further improvement of the quality of combat and political training, with consolidation of military discipline and organization and with high combat readiness.

Closely rallied around Lenin's party and its Central Committee headed by Comrade L. I. Brezhnev, general secretary of the CPSU Central Committee, in single combat formation with the servicemen of the armies of the Warsaw Pact countries, the Soviet servicemen are always ready honorably to fulfill their sacred patriotic and international duty.

The consolidation of the defense might of the motherland of October and the all-round improvement of the USSR Armed Forces are the guarantee of the reliable defense of the socialist fatherland and of the peaceful labor of the Soviet people building communism.

CSO: 1801

'PRAVDA' ANNIVERSARY EDITORIAL ON USSR ARMED FORCES

Moscow PRAVDA in Russian 29 Oct 77 p 1 LD

[Editorial: "The Army is a School of Education"]

[Excerpts] "The protection of the socialist fatherland is the sacred duty of every citizen of the USSR" are words written in our New Constitution. The Soviet people understand that the might and bourgeoning of the motherland are the guarantee of the implementation of the very extensive civil rights and freedoms which it proclaims. Soviet youth have sincerely welcomed the country's fundamental law and approved it wholeheartedly. And now that the time has come for the regular fall draft into the armed forces, yesterday's school students, young workers and kolkhoz members are ready, like their grandfathers and fathers in their time, to relieve the shift of the defenders of October.

Service in our armed forces molds youth in the spirit of communist ideology, deep devotion to the motherland and readiness sacredly to perform their military duty. Genuinely international by nature, the Soviet Army educates soldiers in the spirit of frienship and brotherhood among the peoples of the USSR and reinforces in them the wholesome feeling of a unified family which is inherent in the society of developed socialism.

Modern, complex combat equipment embodies the most advanced achievements of the fatherland's science and industry. Persistent study and much work is necessary to assimilate this equipment to perfection. Military service makes it possible to master the heights of technical skills and implants a desire for firm discipline, order and organization. Of course, it is no coincidence that the knowledge and skills acquired by young people in the armed forces often form the basis of their future civilian professions.

The army molds the collectivist and the individual with wide horizons and firm moral principles. This also applies to the standard of intercourse and mutual relations. Most of today's officers are skillful educators, people with higher education or engineering diplomas and erudite in many fields. Their influence on army youth is of a comprehensive and profound nature, and they help their subordinates to cultivate the best qualities of the builder of communism.

Armed forces commanders, political workers and party and Komsomol organizations are faced with the task of steadily enhancing the educational significance of military service and insuring that not only every year but also every day helps to enrich the personality of the defender of the motherland. A comprehensive approach, insuring the close unity of training in military skills with political and moral education, is particularly important for this. A combination of regulation exactingness and paternal concern for and tutelary attention to the formation of the young soldier is an absolute law in the activity of our officers.

The unity of our people and their armed forces is inseparable. The fate of all Soviet people is linked in one way or another with the army. Some of them have already served in them, others have sent sons and brothers to be soldiers and yet others are bringing up the future defenders of the motherland. Many enterprises and organizations are patrons of military collectives. In their turn the soldiers are making a fitting contribution to the development of the national economy in laying roads, helping in the harvesting and participating in the construction of national economic projects.

The personnel of our army and navy are commemorating the 60th anniversary year with new successes in combat and political training and in strengthening the defense might of the socialist fatherland.

The CPSU Central Committee slogan "Long live the valiant USSR Armed Forces, which stand guard over the gains of October and the peaceful labor of the Soviet people!" is evoking a cordial response among soldiers, those who have been through the army school and those who are just preparing for military service, as well as in the hearts of all Soviet people.

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END